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GEOLOGICAL AND NATURAL HISTORY SURVEY

OF CANADA.

REPORTS AND MAPS

OF

INVESTIGATIONS AND SURVEYS.

TO THE HONOURABLE

THOMAS WHITE,

Minister of the Interior.

SIR,—I have the honour to submit herewith the detailed Annual Report of the Geological and Natural History Survey for 1885.

Though entitled simply the Report for 1885, it will be understood that the examination of a given district frequently requires several years for its satisfactory completion, in consequence of which, portions of the work of previous years, and of office work carried out in the early part of 1886 are included. The various reports comprised in this volume are also issued separately in pamphlet form.

I have the honour to be,

Sir,

Your obedient servant,

GEORGE M. DAWSON.

Ottawa, July, 1886. *Acting Director.*

8834

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.

ALFRED R. C. SELWYN, LL.D., F.R.S., DIRECTOR.

Israel C. Russell
Washington D.C.

ANNUAL REPORT

(NEW SERIES)

VOLUME I.

1885.

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ERRATA.

Page 11 A, line 10 from top, *for* March *read* August.
" 15 A, " 23 " for "*giairers*" read "*graviers*."
" 32 A, " 13 " *for* 1880 *read* 1870.
" 62 A, " 9 from bottom, *for* International *read* Intercolonial.

" 81 C, " 2 " *for S. trigonoceras* read *S. angustigenis*.

" 7 CC, line 7 from top, *for* Hudson Street *read* Hudson Strait.
" 17 CC, " 5 from bottom, *for* Southern *read* Northern.
" 17 CC, " 13 " *for* six *read* three.
" 20 CC, " 16 from top, *for* diloritic *read* chloritic.
" 24 CC, " 21 from top, *for* South *read* North.
" 28 CC, " 4 from bottom, *for* microscopical *read* macroscopical.
" 31 CC, " 5 from bottom, *for* firm *read* green.
" 31 CC, " 12 from top, *for* microscopically *read* macroscopically.
" 33 CC, " 3 " " " " "
" 34 CC, " 9 from bottom, *for* North *read* South.
" 42 CC, " 9 " *for* felsite *read* feeble.
" 43 CC, " 9 from top, omit "just to the south."
" 45 CC, " 17 from top, *for* No. 21 *read* No. 22.
" 46 CC, " 17 from bottom, *for* 21 *read* 22.
" 48 CC, " 17 from bottom, *for* Brick Island *read* Birch Island.
" 52 CC, " 1 from top, *for* microscopical *read* macroscopical.
" 54 CC, line 14 from bottom, *for* Echo *read* Shore.
" 61 CC, foot note, *for* p. 50 CC *read* p. 29 CC.
" 64 CC, line 7 from top, *for* alteration *read* alternation.
" 65 CC, " 1 " *for* send *read* trend.
" 67 CC, " 2 " *for* south *read* north.
" 68 CC, " 4 " " " "
" 72 CC, " 11 " *for* Long *read* Log.
" 78 CC, " 14 from top, *for* south-west *read* south-east.
" 79 CC, " 6 " *for* Brick Island *read* Birch Island.
" 80 CC, " 6 from bottom, *for* south-east *read* north-east.
" 84 CC, " 23 from top, *for* been *read* between.
" 85 CC, No. 9 (in enumeration), *for* Many Island *read* Quarry Island.
" 92 CC, line 15 from top, *for* different *read* definite.
" 97 CC, " 18 " *for* Fly Island *read* Flag Island.
" 98 CC, " 16 " *for* Painted Rock *read* Split Rock.
" 118 CC, " 15 from bottom, *for* Brulé *read* Bare.
" 125 CC, " 5 from bottom, *for* north *read* south.
" 126 CC, " 21 from top, *for* relation *read* reaction.
" 128 CC, " 14 " *for* north *read* south.
" 131 CC, " 9 from top, *for* north *read* south.
" 146 CC, " 11 from bottom, *for* schists *read* silicates.
" 147 CC, " 23 from bottom, *for* slope *read* shape.

" 12 D, " 1 from bottom, *for* assurer *read* assurés.
" 15 D, " 11 from top, *for* Mistassini *read* Mistassinis.
" 25 D, " passim, *for* plageoclase *read* plagioclase.

" 17 DD, " 7 from top, *for* Bessils *read* Bessels.

" 20 E, " 10 from top, *for* Rockland *read* Rockport.
" 37 E, " 3 " " " " "
" 42 E, " 25 " *for* east *read* west.
" 53 E, " 9 from bottom, *for* Silurian *read* Cambro-Silurian.

PLATES AND MAPS ACCOMPANYING THIS REPORT.

MAPS.

PLATES.

SUMMARY REPORT

OF THE

OPERATIONS OF THE GEOLOGICAL SURVEY.

FOR THE YEARS 1884 AND 1885.

The last published Report of Progress of the Survey, that of 1882-83-84 is prefaced by a summary report for the year 1883 to which are added observations on the work of 1884. The present summary report constitutes a statement of work carried on by the survey to the close of 1885, and is practically a reprint of the summary reports forming part III in the reports of the Department of the Interior for 1884 and 1885. Facts of interest noticed in the summary report are thus placed in the hands of the public in advance of the completion of detailed reports and maps, which frequently require to embody the field work of several years. The summary reports also form a connected historical outline of the field and office work of the survey, and a record of the progress of the museum.

1884.

PUBLICATIONS.

The Report of Progress for 1882-83-84 is a royal octavo volume of 783 pages, containing fifteen separate reports and is accompanied by thirty-four maps of which all but two are geologically coloured.

Besides the annual report, a sketch geological map of the whole of the Dominion, on a scale of 40 miles to 1 inch, was prepared, and was published for the meeting of the British Association, together with an explanatory descriptive sketch of the physical geography and geology of the Dominion, in a pamphlet of 55 pages, royal 8vo., by the writer and Dr. G. M. Dawson. This map and pamphlet was

distributed gratuitously to the visiting members of the British Association.

A complete catalogue of the publications of the Survey, from its commencement in 1843 to 1882, was prepared and published in March. (28 pages, royal 8vo.)

Other publications in the biological section were also prepared and issued during the year. These are referred to on a subsequent page.

The greater part of my own time was occupied in matters of administrative detail, which, with duties in connection with the meeting of the British Association in Montreal, left me but little time for personal investigations in the field. From the 11th to 23rd of July I made an excursion along the line of the Canadian Pacific railway, from Ottawa west to Pogamasing, carefully examining the many interesting and instructive cuttings that have been made through the Laurentian and Huronian rocks. A large number of specimens were collected both along the main line by myself, and along the branch from Sudbury to Algoma by Mr. H. P. Brumell, who accompanied and assisted me. In the whole distance, 364 miles, only one metalliferous vein of any importance has been exposed. This is in a small cutting, about four miles west of Sudbury. The ore-bearing rock or vein has a width of 40 yards in the cutting. It apparently consists of iron and copper pyrites, rather coarse diabase or diorite forming the walls. Specimens were collected for analysis, and were found by Mr. Hoffmann to contain 9·08 per cent of copper. (See p. 19 M.) I am informed that the vein has been traced for a considerable distance on both sides of the track on a bearing of 335°. The great thickness of this pyritous vein and its proximity to the railway may render it of considerable importance. In August, before the meeting of the British Association, I accompanied Professor Bonney, who has been for some time engaged in a study of the Archæan rocks of Britain, over the same ground.

The kindness and courtesy of Mr. Archer Baker, General Superintendent Eastern Division Canadian Pacific railway, and also of Mr. Abbott, Chief Engineer at Sudbury, in placing hand-cars at our disposal, greatly facilitated our examination. Indeed it would have been otherwise impossible to have effected it in the short time which Professor Bonney could devote to this excursion.

After the close of the meeting of the Association in Montreal on the 5th of September, I proceeded with the excursion party to the Rocky Mountains, and after our return was engaged in examinations at Rat Portage and along the line of the Pacific railway eastward to Nipegon. I left Port Arthur on the 26th of October and reached Ottawa on the 30th.

Eighteen separate geological explorations were carried out during the summer of 1884, relating to which the following summary reports were submitted.

Explorations and Surveys.

British Columbia and North-West Territory.

On the 9th of May, Mr. Amos Bowman left Ottawa for British Columbia to continue the geological exploration and survey in that province. The first part of the summer was devoted to the lower portion of the Fraser River, its tributary valleys and the adjacent mountain region. The scene of operations was then changed and the remainder of the season devoted to the continuation of the work for the map of the southern interior of British Columbia, referred to in my report for last year. This map covers an area of about 30,000 square miles.

Dr. G. M. Dawson was engaged during the summer of 1884 in continuing and extending the reconnaisance work in the Rocky Mountains, south of the Red Deer River.

Dr. Dawson, with Mr. Jas. White as assistant, left Ottawa on the 21st of May and returned on the 20th October.

Field work was begun from Morley, and the valley of the Kananaskis first examined. Finding a practicable pass from the head waters of this river to those of the Elk, a track-survey was made down the valley of the latter stream, and thence across the watershed eastward to the sources of the Old Man River, and down to the "Gap" of the North Fork. The almost impenetrable character of some parts of this country, together with the very heavy rains of the early summer, rendered progress so slow that it was necessary to make a detour from this point to Pincher Creek to obtain a new supply of provisions. The head waters of the Highwood River, Sheep Creek and the Elbow River were then explored on the way north to Morley. A traverse was next carried through by the Vermilion Pass to the Kootanie and Beaverfoot Rivers, and thence by the Kicking Horse and Columbia valleys and back to the Bow valley by the White Man's Pass.

Dr. Dawson having been requested to meet the party of members of the British Association which visited the West, was then obliged to leave for a few days for that purpose, while Mr. White occupied himself in making a topographical survey of the vicinity of the anthracite coal deposits in the Bow valley.

Later in the season a traverse was made up the Cascade River to the Red Deer and thence westward to the sources of the Bow; and in des-

cending the Bow valley various points of geological interest were examined.

In October, snow storms became so frequent at the high elevations at which it was necessary to carry on the work, that the operations of the season were brought to a close.

The work of the past season, with that of 1883, and surveys of other isolated tracts previously made, furnish data for a reconnaisance map —geological and topographical—of that portion of the Rocky Mountains between the Red Deer and the 49th parallel, embracing an area of about 10,000 square miles. As this portion of the mountains is at present attracting much attention, in consequence of the proximity of the railway, and the maps now existing are quite unservicable, it is proposed to publish the information now in hand, in the form of a preliminary map. This will serve as a guide to prospectors and others, and may eventually form the basis for a more complete map as the surveys progress.

The explorations of the past summer have still further increased the known area of coal-bearing Cretaceous rocks in the mountains, and resulted in their pretty complete definition. The anthracite-bearing rocks in particular, while forming a narrow trough, have now been traced a long way north and south of the originally discovered locality. Deposits of copper ore have lately been found at a number of new localities in this district and efforts are now being made to develop some of the more accessible of these. Fossils were collected in several localities from the Lower Cambrian rocks which underlie the great limestone series of the mountains, and the existence of extensive masses of intrusive (dioritic?) rocks, which in some places contain sodalite and other interesting minerals, determined. About sixty photographs illustrating the magnificent scenery of this part of the mountains and their geological features were obtained, together with a collection of such plants as appeared to be new or interesting.

The work done by Mr. R. G. McConnell during the season of 1884 consisted in completing the geological examination and topography of the country lying between the International boundary and the 51st parallel, and extending eastward from the eastern boundary of Dr. Dawson's map to the third principal meridian. The work in this area also occupied the summer of 1883. All the geological formations occurring in it, ranging from the Middle Cretaceous to the Miocene Tertiary, have been carefully examined and their boundaries, except where masked completely by the drift, determined and mapped with a tolerable degree of accuracy.

Great attention was also given to the topography of the region, and more especially to the hills, ridges and plateaus occuring in it, many of

these being but very imperfectly represented on existing maps, though of great importance in connection with geological outlines. Most of the topographical work, during the summer, was done by his assistant, Mr. D. B. Dowling.

Notes were made on the various soils observed in different parts of the area, and also on the character and quantity of the woods contained in it. [See Report C.]

Mr. J. B. Tyrrell was engaged during the summer in making a geological and topographical examination and survey of the country lying between the 110th and 115th degree W. longitude, and stretching north from the 51st parallel to the North Saskatchewan River, including portions of the drainage areas of the Red Deer and Battle Rivers.

Men and supplies were obtained at Calgary, and field work was commenced on 30th May. From that time till 26th October, the party were traveliing on the open plains in the southern portion of the district, or in the wooded country further north, coming into Calgary three times during the season for supplies.

In the early part of the summer a canoe survey was made of the Red Deer River from the crossing of the Edmonton trail to the mouth of the Rosebud, and during the rest of the season, track surveys, with odometer measurements where possible, were made of the country passed over. Notes were taken of its general character, and the southern edge of the woods can now be denoted with some degree of accuracy.

Several compact seams of lignite were met with, which will furnish an abundant supply of fuel, and in some places, in the vicinity of the Red Deer River, a large amount of ironstone was also seen.

The conglomerates discovered last year by Mr. McConnell in the Cypress Hills were found to occur also in the Hand Hills, covering a considerable area.

Collections were made of the different rocks seen in the district, as well as of any fossils that could be obtained without too great delays.

The measurements, and traverses made with estimated distances during the year aggregated 2625 miles.

ONTARIO.

Mr. A. C. Lawson's work in the Lake of the Woods region was in continuation and completion of that undertaken by him during the previous season as Dr. Bell's assistant, viz.—the prosecution of a detailed topographical and geological survey of the northern half of the Lake of the Woods, or that portion of it embraced within the limits of the Huronian belt of rocks, which are here of much interest, not only from an economic point of view as comprising the gold-mining area,

but also as exhibiting, by the great extent of their exposure and ease of access, the leading lithological and structural features of this metalliferous series, as well as its relations—here clearly shown—to the underlying Laurentian rocks, thus affording us a key to the elucidation of similar belts in less accessible regions.

Mr. Lawson, accompanied by Mr. J. W. Tyrrell, C. E., and Mr. W. F. Ferrier, left Toronto for the scene of operations on 27th May, and engaging canoe-men at Sault Ste. Marie commenced work at Rat Portage 31st May, returning from the field October 29th.

In the course of the season the whole of the shores of the portion of the lake under survey, together with Shoal Lake and the numerous islands which occupy to so large an extent both lakes, were carefully examined and surveyed, and specimens of all the typical rocks of the Huronian belt collected. Particular attention was paid to the character and structure of the rocks in the neighborhood of the chief auriferous veins, with the object of ascertaining, if possible, the general law governing their occurrence; and in this some measure of success has been attained, since it seems to be generally true that the largest and richest lodes are in proximity to intrusive masses of igneous rocks. The general confines of the Huronian belt were defined with greater certainty, and our knowledge of its distribution extended to the southeast.

In the country adjacent to the Lake of the Woods, log surveys and geological examinations were made of the lakes stretching eastward from the Lake of the Woods towards Vermilion Bay, and of Crow Lake to the south-east. An examination was also made of the country crossed by the canoe route between Sabaskong Bay and Rainy Lake. While in the vicinity of Fort Francis, Mr. Lawson took the opportunity of opening two of the mounds on the Rainy River, situated on Mr. McKinstry's farm, and succeeded in obtaining a number of ancient Indian relics of archæological interest.

Mr. E. D. Ingall proceeded, on 1st July, to Lake Superior, to report on the mining developments of that region. He first coasted down the north shore of the lake, from Port Arthur to Sault Ste. Marie, examining all the chief mining locations. Then, after visiting the mines in the Sault Ste. Marie district, he returned to Port Arthur, from whence he made trips to the recently opened mining district at Kaministiqua, on the Canadian Pacific railway, and the mineral discoveries in the vicinity of the Rabbit Mountain and Whitefish Lake. After remaining there a short time, to collect information from persons interested in and conversant with the mines of the district, he returned to Ottawa on the 18th November.

Mr. E. Coste has been engaged in investigations in the gold and iron

ore bearing region in the counties of Hastings and Peterboro,' on which he reports as follows:—

"From the 1st of May to the 10th June, the iron ore deposits in the townships of Madoc, Marmora and Belmont were examined, and the iron mines being developed in the townships of Tudor and Wollaston were inspected. This preliminary work demonstrates that there is a very good, though small, auriferous district around Deloro, in Marmora, and also that the iron ore deposits, both of hæmatite and magnetite, are numerous and important.

"On the 10th June a systematic survey of this region was commenced and steadily pursued until the 25th October, when bad weather and snow terminated field operations. During these four months the northern boundary of the limestone formation (Cambro-Silurian) has been traced and mapped in detail from Stocco Lake, in Hungerford, to Burleigh Falls, in the township of Smith, as well as the numerous detached patches which were found to be greater in number than shown on any existing map. It is of practical importance to define exactly the limits of these limestone deposits. As sources of limestone and perhaps also of lithographic stone they are themselves valuable. They rest horizontally on the crystalline rocks, and their margins thus limit the areas in which the gold veins and iron ores may be looked for. These, in North Hastings, and probably elsewhere in this region, are associated with certain granitic masses, around which they all occur. To trace out and map these eruptive masses is, therefore, also important. Three such masses, the Huckleberry Rocks, the mass forming Coe Hills in Wollaston, and the one called Red Mountains, in the township of Lake, were mapped, and steps were being taken to map the two masses, on the borders of which are the Emily and Baker mines, when field operations were suspended.

"During all these excursions close attention was given to the crystalline Archæan rocks and the conclusion was arrived at that the true Huronian series is represented in North Hastings, but conformably following the inferior crystalline limestones, schists and gneisses of the Laurentian, and thus agreeing with the result of observations in the Lake of the Woods region, where auriferous veins and iron ores also occur under corresponding conditions in the Huronian rocks."

In November Mr. Coste visited West Portland township to examine and report on some phosphate mines.

From the 14th to the 21st of November he was engaged inspecting some of the mines in the Eastern Townships, including the Capelton copper mines, an iron ore deposit at Sherbrooke, two asbestos mines at Black Lake, in Coleraine, and the lime works at Marbleton, in Dudswell township. Two of the copper mines of Capelton were in active

operation; the Crown mine, Orford Copper and Sulphur Company, and the Albert mine, G. H. Nicholls & Co. The former has a shaft 1150 feet deep. The ore averages 3 per cent. to 4 per cent. of copper and 40 per cent. sulphur. The vein or bed is a long one, and in places as much as 35 feet wide. A third company, the Canadian Copper and Sulphur Company, whose works are on the same vein, and on another parallel one, about 800 feet to the southeast, suspended operations in May last, because they were losing the sulphur, and the low prices obtainable for copper did not pay. This company now proposes to amalgamate with the Huntington mine in Bolton, and to erect sulphuric acid works for the complete utilization of the ore.

A number of specimens were collected, and reports of the season's work, with observations on the laws, and customs, and regulations affecting mining development in Canada, were prepared by Mr. Coste during the winter.

Mr. A. Cochrane was entrusted with the topographical measurements and surveys required in connection with Mr. Coste's exploration. This work embraced micrometer surveys of lakes and rivers, and many of the travelled roads. over an area of about 350 square miles in the townships of Rawdon, Huntington, Madoc, Marmora, Wollaston and Belmont; also, accurate instrumental surveys of various gold and iron mines.

Quebec and North-East Territory.

Surveys and explorations have been carried on during the year in several parts of Quebec and the North-east Territory. Mr. R. Ells made a micrometer survey of the Causupscull River, a tributary of the Metapedia, for 45 miles, to its head waters, with a view to making the topography of the quarter sheet map, now being engraved, more perfect, and at the same time to determine with greater accuracy the limits on this river of the great inland Devonian area previously described * in the Gaspé Peninsula.

Early in the year, steps were taken to organize an expedition for the purpose of extending the exploration and survey—commenced in 1870 and continued in 1871—of the, as yet, but little known region to the north of Lake St. John, including the completion of the survey of Lake Mistassini, and an examination of the country between it and the shores of James' Bay. The co-operation of the Provincial Government in carrying out the expedition was solicited, and after considerable negociation, a sum of $1,500 was granted by it. After consultation with the Honorable Mr. Lynch and with E. E. Taché, the

* Report of Progress, 1880-81-82.

Assistant Commissioner of Crown Lands, Mr. John Bignell, P. L. S., was selected to take charge of the party, and Mr. A. P. Low, of this branch, was appointed as geologist and second officer in charge.

On the 13th of May, a credit was issued by me to Mr. Bignell for $3,000, and he was instructed to engage men and make all necessary arrangements to start as soon as possible, with the understanding that the expedition would pass the winter at Mistassini. He was furnished with tracings of the plans of the surveys of 1870 and 1871, and for his further guidance a memorandum was given him, stating generally the objects of the expedition, and also instructions drawn up by the Assistant Commissioner of Crown Lands at Quebec, and approved by myself.

Memorandum, Mistassini Exploration.

The expedition should start as early in July as possible. The objects of the expedition are :—

1st. A thorough survey, hydrographical and topographical, of Lake Mistassini, especially of the northern and eastern portions not examined or surveyed by the Geological Survey parties under Messrs. Richardson and McOuat, in 1870-71.

2nd. A geological examination of the lake shore and of as much of the adjacent country as may be practicable.

3rd. The collection of specimens, vegetable, mineral and animal, illustrating the resources of the region.

It is also important that a survey should be made of the Rupert River, through which the waters of Lake Mistassini discharge into James' Bay. This will probably require another season's work, unless the party can conveniently separate, and while one was engaged surveying the lake, the other could descend the Rupert River and perhaps return by the East Main River or by any of the other large rivers which discharge into the east side of James' Bay. This plan would afford a larger amount of information relating to those portions of the north-eastern territories of the Dominion and adjacent portions of the province of Quebec south of the height of land, which lie between the 72nd and 79th degrees of longitude and the 50th and 52nd degrees of latitude, an area of about 42,000 square miles, of which at present very little is known, but which, there is reason to believe, may contain valuable minerals and areas of land fit for settlement. Two routes from Lake St. John to Mistassini have already been explored and surveyed by the Geological Survey, as well as a large extent of the shores of the lake northward to the outlet on the west side. The

reports of these expeditions are published in the Progress Report Geological Survey for 1870-71 and 1871-72, and the plans of them on a scale of 4 miles to 1 inch are in the office of the Survey.

Surveys could be carried on at intervals this winter around the lake, and in the spring these could be extended by the Rupert or East Main River to James' Bay; and while the expenditure for the second season would be very considerably less than will be required this season, the result might be expected to be infinitely greater. The precise route to be followed after starting must be left to the discretion of the leaders, who will in this be guided by circumstances.

The following are the instructions given, as stated, to Mr. Bignell by the Department of Crown Lands, Quebec :—

Letter of Instructions.

SIR,—The Legislative Assembly of this province having voted a sum of $1,500 in favor of an exploration to Grand Lake Mistassini, which is about to be undertaken by the Federal Government, I am directed by the Honorable the Commissioner of Crown Lands, to inform you that you have been nominated to take charge of one of the exploring parties under the general control of Dr. Selwyn, Director of the Geological Survey of Canada.

The route you are requested to adopt is the following :—

Starting from Grand Lake Pipmuakan, you will go up the River Betsiamites as far as Lake Manouanis, near the source of that river, and the position of which has been determined by you some years ago. From Lake Manouanis to Grand Lake Mistassini, you will travel in a westerly direction, following the streams and lakes forming the heads or sources of rivers flowing south into Lake St. John, or in the opposite direction, and you will also pass by Grand Lake Manouan, of which mention was made to you by the Indians at the time of your last survey of that region.

On your whole way to Mistassini, as above indicated, you will make a regular survey or scaling of the different rivers, lakes, portages, &c., you will follow as your route, estimating the distances with the "micrometre Rochon," and measuring the angles with the theodolite.

During the course of your survey you will make astronomical observations as often as circumstances will allow you to do so, in order to determine the meridian and latitude of different points of your route.

You are also requested to give the usual information respecting soil, timber, &c., in the same manner as you have done for your survey of

the Outardes, performed some years ago. You will also furnish this office with a complete copy of your plan of survey and of all similar work performed by any of your party.

Signed,

E. E. TACHÉ,

Assistant Commissioner.

I fully expected Mr. Bignell would start not later than July, and was much surprised to learn from Mr. Low that he did not leave Bersimis—the route by the Bersimis or Betsiamites River having been determined on—till the 20th March. I had received no communication from Mr. Bignell since the 18th of August, at the close of the year. I had, however, received letters from Mr. Low, dated Lake Pipmuakan, August 25th and September 1st, and Lake Manouan the 9th of October. The following are extracts from these letters:—

"Pipmuakan Lake, 1st September.—At a distance of 65 miles up the river Bersimis a yellow gneiss occurs. This rock is highly charged with magnetite, and its action, combined with that of the weather, upon the felspar, may account for the decomposition of the latter, for beyond this place these rocks were found to be quite friable, and made up of grains of yellow quartz and magnetite; and from this I believe the great beds of yellow sand and black magnetic sand are formed, which are found everywhere along the river and coast. In some cases, the rock consists almost entirely of magnetite, in beds from 1 to 20 feet thick, as seen along the river and on the portages for a distance of 40 miles, and these must contain a vast amount of valuable ore.

"At 105 miles from the coast a pink crystalline limestone occurs, containing crystals of mica, sphene and Labrador felspar A short distance beyond this exposure a dark bluish, fine grained labradorite was found. From this point, 135 miles from the coast, I have seen only a succession of coarse and fine grained labradorite rock. I have collected specimens of the different rocks, and send them with this letter to Bersimis, whence Mr. Burgess has promised to forward them to Ottawa.

"The river, for forty-five miles from its mouth, is quite navigable; and its banks and the neighboring mountains are clothed with a good growth of timber, consisting chiefly of spruce, red pine, birch, tamarac, poplar and balsam. At the distance named there is a fall of about 100 feet, and above this, for forty miles, the river is a succession of falls and rapids. It then becomes quite navigable to the lake, there being only one rapid past which a portage is requisite. The timber extends only about eight miles above the first fall. Above this there is only a

second growth, seldom exceeding eight inches in diameter, and principally spruce, birch and poplar, with a few tamarac, pine and balsam. The whole country has been burnt over not many years ago.

"The hills along the river, for 100 miles from the sea, vary from 800 to 1,200 feet in height; beyond this, they diminish gradually in altitude till, around this lake, they are not more than 300 or 400 feet high.

"The river above the falls abounds with fish, and we have taken large pike, suckers and brook-trout in the nets. Below the falls there are a few sea-trout and salmon.

* * * * * * *

"Since my last letter from Lake Pipmuakan, 1st September, I returned down the line forty-five miles to meet Mr. Bignell, who did not leave Bersimis until 20th August, and we did not leave Lake Pipmuakan until the 10th of September. Then I again left Mr. Bignell for Lake Manouan *via* the Manouan River. Mr. Bignell continued up the Bersimis River. I have now completed my work and am waiting Mr. Bignell on the west side of Lake Manouan. The distance passed over I estimated at nearly 100 miles. Much time was lost on account of being unable to cross the large lakes in high wind, as our canoes are too small to stand the sea.

"The weather has also been very unfavorable. From this point, Lake Manouan, there is a portage route to Lake Onouistagan on the Peribonka River, which takes three days; thence we go up the Peribonka for three days, and then proceed by a western branch to a chain of lakes on the height of land, and from there by several lakes to Lake Mistassini. We will be unable to get further than the height of land in canoes, as all the small lakes will be frozen over. The labradorite rocks I found to extend only about two miles west along the shores of Lake Pipmuakan, and from that point to here I have found only red and grey gneiss, with no economic minerals, except in a band of crystalline limestone, on two small lakes east of Lake Manouan, which contained large crystals of mica, some of them eight to ten inches across. The country between Lakes Pipmuakan and Manouan is flat and covered with many lakes, only one range of hills, of about 800 feet high being passed on the Manouan River. The country has all been traversed by fires and the timber is all burnt. Game is very scarce here and but few fish are caught in the nets.

"We expect to reach Mistassini between the 15th and 30th of November. We had the first snow storm yesterday, 8th of October, and the ground is covered with about three inches of snow. Since the 10th of September the thermometer has fallen below 32° every night."

A supply of provisions, for the uses of the party during the winter and spring, was forwarded to the post on Lake Mistassini. Mr. F. H. Bignell, who had charge of this expedition, left Lake St. John with the provisions on the 16th of July, with six canoes and nineteen men. Ten of these were discharged on the 6th of August, thirty-five miles up Chief River, and the post was reached with all the provisions on the 10th of September. There seven more of the men were discharged and were allowed seven days provisions and twelve days pay to return direct to Lake St. John. Mr. F. H. Bignell, with two men, then proceeded towards where it was supposed the main expedition would enter Little Lake Mistassini.

His report of this trip is as follows :—

"I then travelled towards Themiscomie Lake to meet the main expedition, as that was the only practicable route for the latter to first strike Little Mistassini. In so doing I navigated Great Mistassini for 120 miles from Foam Bay, also retracing my journey some sixty miles, as there was another route which the main expedition might possibly follow. I then effected the crossing to Little Mistassini, a distance of some six miles, by portages and four small lakes, and travelled eighty miles towards its head. The general trend of the smaller lake seems the same as that of the great lake—south-west to north-east.

"About thirty-five miles from the head of Little Mistassini, the Rupert enters and flows out of it again, the inlet and outlet being almost opposite each other, and both bearing the same name. The outlet from Little into Great Mistassini is not more than 1½ miles long, but it is exceedingly broken by rapids. Little Mistassini is supposed to be 100 miles in length, but, if I saw its greatest width, it is not more than six miles broad at its broadest point. I did not visit the southern shores of Little Mistassini, except where I struck them near the head, to portage to the Rupert, and there I remarked that they are sandy; but the southern shores look very beautiful from the north, the land coming down to the water's edge in a gradual slope, and being clothed with spruce and other trees—which seemed of a fair size—but no pine.

"Along the north shore, which I coasted, islands are numerous ; the banks are generally low, and in most parts composed of solid limestone, forming a natural wharf, with numerous fissures, varying in width from 1½ to 10 inches.

"I did not run up the Rupert River from Little Mistassini, but struck it from towards the head of the lake by a portage of about 2½ miles. The part of the Rupert that I travelled, some twenty-five miles, comes from an east direction, and the river is a large and noble one.

"Leaving the Rupert we reached Themisconic Lake on the 23rd September, and found there an old abandoned Hudson's Bay post, built

of square spruce logs. Although the building looked old, it seemed still good. We discovered no traces of the main expedition, but we did not yet relinquish hope of meeting it, and though the region was a wild one, and perfectly unknown to us, we managed to extricate ourselves very creditably by pushing on through the portages and lakes till we crossed the height of land and struck the waters flowing into the Shipshaw River, into the Manouan, and by the Manouan into the large Peribonka, finally arriving back at Lake St. John on the 8th of October, without having the satisfaction of meeting the main expedition, which appears to have reached the Shipshaw River after we had passed that place. I should mention that the guide of my party, who was to have remained to guide the main expedition around Great Mistassini and down the Rupert River to James Bay and return, objected so to do and returned to Lake St. John. I wrote a letter to the main expedition, warning them of all this, but I am not aware whether it will be easy for them to replace him. The delay in sending in my report is due to the fact that I expected and have since received a letter from the main expedition, which I thought would be of more importance and call for insertion in my report. However, I may be permitted to extract from it the intelligence that on the 12th October they were at Lake Manouan, some 285 miles from Bersimis River, by canoe route; that they were then all well and fully expected to reach Mistassini in canoes. I should not omit to mention that I was greatly indebted to Mr. John H. Commins, officer in charge of the Hudson's Bay Company's post, at Lake St. John, and Mr. Miller, officer in charge at Mistassini post, for kind assistance in every way within their power."

[For a detailed report on Lake Mistassini see report D.]

The Rev. Professor Laflamme, of Laval University was requested to continue and extend the investigations which he commenced in 1883, the report on which appeared in the volume of Geological Reports for 1882-83-84.

Respecting his work of the present season, the following short notes have been received, and translated from the original manuscript, by the writer:—

"I regret that serious illness, arising chiefly from the bad weather experienced, obliged me to discontinue the researches which you asked me to undertake in the Saguenay region, during the past summer. Notwithstanding this, I have been able to determine, with sufficient precision, the limit of the Cambro-Siluran strata, which occur on the south-east side of Lake St. John, and also to note the patches of the Utica and Hudson River formations, which, in various places, cover the Trenton limestone.

"Nothing of special interest was observed relating to the Trenton formation, except that in several localities it affords an excellent building stone. The banks of the River Ouiatchouan, from the lake to the great fall, which marks the commencement of the Laurentian gneiss, may be specially mentioned. The beds are horizontal and thick, and the stone is easily dressed. It is, however, in some respects inferior to that obtained elsewhere. The Deschambault stone, especially, is very superior.

"In my report for 1883,* the probability of the existence of another basin of Cambro-Silurian age, besides those of Lake St. John and Ste. Anne, was stated. This conviction is confirmed by observations, and it is now proved that the Trenton limestone occurs over a large area in the parishes of St. Alphonse and St. Alexis, though it is often concealed by a considerable thickness of the overlying glacial clay deposits.

"A marked character of the Utica shales which I have examined, is the large quantity of bitumen they hold. One of the large islands in Lake St. John, Ile Traverse, is largely covered with *débris* of these schists. These were, some time since, accidently ignited by a fire made on the shore, and burned for eighteen months, neither rain or snow being sufficient to extinguish them, and it required nothing less than an extraordinary rise of the lake to completely drown this strange furnace.† The "*giairers*" which have been thus burned have changed color, and through a thickness of five or six feet they now constitute a compact conglomerate.

"Some have supposed that these Utica shales could be used for roofing slate, but they have neither the consistence nor strength sufficient for that purpose.

"On a long excursion made up the Ashuapmouchouan River, I convinced myself of the immense extent of arable soil in this part of the country. These quaternary marine clays are all extraordinarily fertile, and colonization can find an important outlet in this direction. There are areas, bordering on the large rivers, in which the clay is covered by a thick layer of sand. Though I was not able to find a single fossil, I am induced to regard these sands as being more recent than the Saxicava sand of Dawson. They appear to resemble the sands now being formed by the rivers.‡

* Report of Progress for 1882-83-84, Report D.

† This bituminous character of the Utica shales has long been known, and is fully described in the Geology of Canada, Chapters X, XVII and XXI.—A. R. C. S.

‡ They are probably similar in character and origin to those described in Chapter XXII, Geology and Canada, 1863, as the Saugeen clays and sands, in which also no shells have been found.—A. R. C. S.

The distinct traces of shore lines which were observed at about 250 feet above the actual level of the lake, afford some idea of the depth of the quarternary ocean which invaded this region after the retreat (*passage*) of the glacier.

The foregoing are the principal facts observed during this brief examination. I regret not having been able to complete my investigations, especially in reference to the Cambro-Silurian basin of Ste. Anne."

In the report for 1883 it was mentioned that Mr. Adams had spent about two and a half months in field work about Lake St. John and Kenogami and the discharges of the Saguenay. This work was continued and extended during the past summer, and his report on it is as follows :—

"In accordance with instructions, I spent four months during the past summer in the Saguenay district. The area explored, containing about 3500 square miles, lies to the north of Lake St. John and the discharge of the Saguenay River, and is traversed by the Rivers Peribonka, Little Peribonka, Aulnais and Shipshaw, all of which were examined. It was ascertained that the anorthosite rocks, found by Mr. Richardson in 1857 about Lake St. John, extend much further to the north and east than has been hitherto supposed. They were found exposed along the Peribonka for over one hundred miles from Lake St. John, and on the Shipshaw to a point four miles north of Lake Pamouscachiou, which was as far north as these rivers were examined, and in neither case was the limit of the anorthosite rocks reached. As similar rocks are largely developed on the River Moisie, it seems not improbable that the anorthosite rocks in these two areas are really continuous. To ascertain whether this is really the case, it will be necessary to examine the upper portions of the rivers Bustard and Manicouagan, and they should also be found on the Bersimis River.

"Numerous deposits of iron ore, some of them very extensive, were observed about the Discharge of the Saguenay. The specimens of these ores which were collected have not yet been examined, but judging from the iron ores occurring in similar rocks elsewhere, they will probably be found to be titaniferous."

It having been decided in the spring to send an expedition to Hudson's Bay to make investigations in reference to the navigation of the bay and straits, and to establish stations for observation during the winter, it was thought desirable that Dr. R. Bell, who had already made several explorations around Hudson's Bay, should accompany this expedition, to act as medical officer, and to make observations on the natural resources of the region—mineral, vegetable and animal—and such collections as time and opportunity should permit.

Lieutenant Gordon, R.N., commanded the expedition. It left Halifax on the 22nd July, in the Newfoundland sealing steamer "Neptune," and returned to St. Johns on the 11th October. Dr. Bell states as follows respecting this expedition :—

"The Labrador coast was reached at Blanc Sablon, thence followed round to Ford's Harbor and Nain, where one day was spent. Nachvak was the next place touched at, and thence the vessel proceeded to Cape Chudleigh, near which the first observing station was built. Crossing to the north side of Hudson's Strait, Resolution and the Lower Savage Islands were sighted, but the stormy weather prevented landing. The Upper Savage Island was then reached, and here, a short distance east of North Bluff, the second station was established. Thence we crossed to Cape Prince of Wales, the site chosen for the third station; and the fourth was built on Nottingham Island. Recrossing the straits and entering Hudson's Bay, a suitable site for a station was unsuccessfully sought for on Mansfield Island. Thence passing close along the south-east side of Southampton Island, the entrance of Chesterfield Inlet was made. We landed on Marble Island, and then made for Cape Churchill, and anchored in Churchill Harbor, from the 6th to the 9th of September. York Factory was next visited, and left on the 12th September. From there we made Digges Island, on the south side of the western entrance to Hudson's Strait, on the 15th. Here the fifth station was established. On the return voyage through the straits, all the stations were visited, and a second unsuccessful attempt was made to land on Resolution Island. We then proceeded down the Labrador coast to Nachvak, where the sixth observatory was established, and on 6th October we left there for St. Johns."

It will be readily understood that the few places touched at and the short time spent on shore at each, precluded the possibility of any large amount of geological or other scientific observation being effected. About sixty interesting photographs were taken by Dr. Bell.

New Brunswick and Nova Scotia.

In New Brunswick some time was spent by Mr. Ells in examining the copper deposits of eastern Westmoreland, which, in consideration of the large amount of capital now being expended here, must be regarded as of economic importance. In this connection it may be remarked that the peculiar copper deposits which have been so largely developed at Dorchester, are of considerable extent, traces being found at many points on Cape Maringouin peninsula, as well as in the south-ern parts of Albert county, and at various places in the counties of Cumberland and Colchester, in Nova Scotia. At none of these locali-

ties, however, are the deposits apparently so extensive as at the Colonial Copper Mining Company's area, and that adjoining to the south. On this property a large amount of work has been done, and at the time of Mr. Ells' last visit, in October, about forty-five men were employed. This copper deposit has already been described in former reports as occurring near the contact of the millstone grit with the Lower Carboniferous red marly shales. The ore occurs in small pockets or bunches, where it has been precipitated by the deoxidising action of the organic matter of the plant stems upon copper in solution, and is often associated with small layers of coaly matter. A band of grey sandstone, about 8 to 10 feet thick, is now being mined, which carries grey copper ore in a fine state of division, disseminated through the bed, to the extent of from 4 to 6 per cent., according to the manager's assay. Experments are now being made with a view to concentrate this ore on the spot, the result of which has not yet been made known. The band of sandstone containing this copper ore extends for several miles. The ore was seen in beds of both Upper and Lower Carboniferous age.

The coal seams reported to occur to the north of Sackville were found on examination to range from two to six inches, and are therefore of no economic value. The productive coal measures are apparently wanting in this locality, the Upper Carboniferous resting upon the millstone grit in which the coal seams referred to occur.

...le of gold was seen in a piece of quartz, said to have been ...ing a well in New Annan. The ledges whence it was ... could not be seen, but the rocks in that vicinity—talcose, ...ists of pre-Cambrian aspect—are intersected in places ...ar veins of quartz similar to those in the pre-Cambrian of ...runswick, and ... gold bearing.

ne... Professor Bailey cont... the surveys in New Brunswick. His work
M... in the field extended ov... a period of two months and a-half, and in
...ldition to the duties of ...ral direction and supervision, embraced
ob... the special study of the contact lines of the different formations, the
the... systems of movement to which these have been subjected, their various
ing... degrees of alteration and the collection of their contained fossils. A
pr... detailed report on those several points is being prepared. His assistants for the season were Mr. W. McInnis and Mr. J. W. Bailey. The former took the field on the 1st of June and continued work until about the third week in October; the latter beginning on the 1st of July, continued work to the same date. Mr. McInnes, in addition to affording Professor Bailey special assistance when required, undertook the entire charge of the topographical part of the work. This included the measurement with the odomoter of 252 miles of roads, and the making surveys by pacing about 18 miles of other roads and streams that were too rough for the odomoter.

In all these surveys, notes were taken of the geology and surface features, sufficient for the compilation of an approximately correct topographical and geological map of the region examined, which embraces the larger portion of Carleton county and parts of the counties of Victoria, Northumberland and York, and is included in sheet 2, S.W.

Mr. J. W. Bailey assisted both Mr. McInnis and Professor Bailey in the ordinary routine of camping, in the collection of fossils and in the exploration of streams and comparatively inaccessible regions. Special attention was also paid by him to the surface features of the regions explored, including the determination of altitudes and the outlining of prominent ridges and valleys, the results of which observations will be incorporated in the map already referred to.

In addition to the fossils collected in different portions of Carleton and Victoria counties, which are mostly of Silurian age, others of the same age were also collected from certain localities in Charlotte county, together with still others from rocks of Cambrian age in St. John county. The former have been sent to the Survey office for determination; the latter have been entrusted to Mr. G. F. Matthew, by whom the Lower Cambrian fauna has been made a subject of special investigation.

The exploration relating to the surface geology of New Brunswick, carried on by Mr. Robert Chalmers during the season of 1885, extended to all parts of the province, and a number of interesting observations were made. The work commenced on the 7th May. During that month, portions of Albert and Westmoreland counties were examined, and early in June Mr. Chalmers proceeded to the Baie des Chaleurs district, spending ten days between Bathurst and the mouth of the Metapedia. He then went to Kent county for three or four days; thence proceeded to Northumberland, where he was occupied till the 21st of June. From the latter date to the 10th of July was spent in making further examinations around the Baie des Chaleurs, from Caraquet to the mouth of the Upsalquitch, on the south side, and westward on the north side as far as Paspebiac, visiting all the back settlements between the Nipisiquit and the Restigouche, and ascending several small rivers short distances. On 15th July, he left St. John for the Tobique River, and hiring two Indians with canoes there, he started from Andover on the 19th, accompanied by Mr. George U. Hay, botanist of St. John, as a volunteer. The trip occupied fifteen days, in the course of which the river was ascended to its source. Nictor Lake was crossed to Nipisiguit Lake, measuring their heights barometrically. Some of the highest peaks along the route were ascended, and many facts were obtained relating to the flora and agricultural character of the region traversed. On the return trip

to St. John, a short time was spent re-examining the terraces below Grand Falls and in the Keswick valley, and the necessary data obtained for preparing drawings of the sections illustrating Mr. Chalmers' report of progress, [1882-83-84, Report G.G.] St. John was reached on 18th August, and a few days spent there preparing the drawings referred to, and making detailed examinations of Lily Lake and other places in that vicinity.

On the 26th of August Mr. Chalmers left for the northern part of the province, and having secured two canoemen at Bathurst, started on a canoe trip up the Nipisiguit, ascending that river to its source, thence returning to Portage Brook, and crossing over to Upsalquitch Lake he descended Upsalquitch River, reaching Campbellton on the 19th September. Between that date and the 26th, the time was occupied in making some additional observations on the Restigouche and at other points on the Baie des Chaleurs. He then started up the South-west Miramichi, following it from Newcastle to the head of settlement—10 to 12 miles above Boistown, and obtained some important facts. From Boistown he proceeded across the country to Fredericton, and thence to St. John. In the early part of October, a few days were occupied in correcting proof sheets of his report and in examining Lawlors, Douglas, Latimer and other lakes lying in the north-east part of St. John county. On the 13th October he left for Sackville and Amherst, and while there, thought it advisable to go to Herbert River, N. S., which he did by way of Spring Hill, to see the "Boar's Back," a remarkable kame described in Acadian Geology. Returning, he examined the brick clay at Moncton and remained a day at Petitcodiac, reaching St. John on the 18th.

On the 20th he went to St. Stephen and thence proceeded up the St. John to Edmundston. Examined the valley of the Madawaska north to the Quebec boundary, finding striæ and evidence of post-glacial lakes or lake expansions along the course. On the return trip he re-examined the St. John valley at the mouth of the Aroostook and at some points below that place.

The remainder of the season, with the exception of two days spent going to Fredericton to obtain barometric readings from Professor Harrison, was devoted to the study of the region around the mouth of the St. John, and westward to the head of the Long Reach, also along the Bay of Fundy coast to the Charlotte county boundary. Specimens of clays were collected at several of the principal brick yards, and quaternary fossils from the Baie des Chaleurs district.

On the 12th November he left St. John for Belledune; on the 13th he went to Bathurst to get some meteorological data at the station kept there, and on the 14th started for Ottawa.

The surveys and explorations made during the year 1884 by Mr. Ells, in the province of Nova Scotia, were confined principally to the counties of Cumberland and Colchester, with the view of completing the quarter-sheet map adjoining those already published of southern New Brunswick, and of getting the large amount of work already done by Messrs. Barlow and McOuat* ready for publication. The first half of the season was devoted to the examination of the structure of the Cobequid mountain range, including the relations and extent of the iron ore deposits along its south side, which were traced from the North River, to the northward of Truro, to the Harrington River, below Five Islands, a distance of over forty miles. Surveys were made of most of the streams flowing from the mountains to the Basin of Minas. These afford excellent sections of the various formations in this area. The horizon of the iron ore is easily recognized, both by its lithological character and its associated minerals. Veins of iron ore of considerable size were found as far west as Five Islands, beyond which the formation was not traced.

The baryta which was formerly mined on the Bass River undoubtedly belongs to the same formation, and the mineral also occurs in connection with the iron ore at the Londonderry mines. The extension of the iron-bearing belt east of Truro has not yet been traced continously, but from the character of the iron ores and their associated rocks, it seems very probable that the deposits lying to the north of the West River of Pictou are a part of the same band. It will therefore be seen to be a formation of great extent and economic importance.

In connection also with the iron ores, an examination was made of the deposit found near Brookfield, about eight miles south of Truro, where masses of iron ore, similar to much of that found at Londonderry, lie scattered over the surface. Explorations during the past season by Mr. R. E. Chambers have resulted in finding the vein of ore from which these loose masses were probably derived.

On the north side of the Cobequid Mountains, the copper deposits of the French River, Malagash, and other points were examined, but these were not found to be sufficiently extensive to be of much economic value. The country to the north was carefully surveyed by Messrs. Giroux and Barlow, who ran extensive chained lines in order to complete the map of this area commenced by Mr. Scott Barlow some years ago. The structure of the Spring Hill coal area was studied with the object of determining the prospect of finding the thick seams of that locality further to the north and west.

The presence of infusorial earth of great purity and in large quan-

* Vide Report of Progress, 1873-74.

tity was noted in Folly Lake, on the line of the Intercolonial Railway, near the summit of the Cobequids. The bed of the lake, over a great part of its extent, appears to be composed of this substance. Its value for the manufacture of fine brick and non-conductive boiler covering is very great, and the deposit will doubtless be speedily utilized for these and other purposes.

Towards the close of the season, a visit was made to Digby, to examine the iron ore deposits of the North Mountain, or Triassic trap range, near that town. The iron was found to be a magnetite of excellent quality, and to occur in considerable quantities, with the prospect of cheap and easy surface mining.

Deposits of magnetite occur in this range throughout the greater portion of its length, but in general they have been considered too small and uncertain to be developed to any extent. The deposit at Digby appears to be the most considerable of any heretofore seen in that formation.

During the season, Mr. Ells was assisted by Messrs. N. J. Giroux, C. E., and A. E. Barlow, B.A., both of whom were with him during the preceding season; also, for a short time, by Mr. R. E. Chambers, B.A.

The field work extended from 13th May to 21st November.

In connection with the exploration, about 1,000 miles of roads and streams were measured, as follows:—

	Miles.
Chained Roads	264½
Micrometer surveys	64
Paced Roads	275
Paced streams	100
Odometer surveys	300

Mr. H. Fletcher was occupied, during the summer of 1884 in the counties of Guysboro' and Antigonish, N.S., east of the West River of Antigonish, and East River of St. Mary's, west of the district examined in 1879, about Havre au Bouche and the Strait of Canso, and north of that surveyed in 1883, along Guysboro' Harbor and the Salmon River.

The country to the westward of the St. Mary's River and south of the West Branch, iucluding the Liscomb River and other steams near the Halifax county line, was surveyed by Mr. E. R. Faribault, C.E., of the geological staff, assisted by Mr. A. McLeod, Archibald Cameron and John Smith; while to Mr. John McMillan, assisted by J. A. Robert, B.A., sen., and W. T. McLeod, was entrusted the country south of the Melrose road, between St. Mary's River and Country Harbor. Both

areas, embracing about 773 square miles, are occupied by the whin slate (Lower Cambrian) and accompanying granite of the auriferous series of Nova Scotia, the boundaries of which have been carefully traced and material collected for the preparation of a map of this interesting region, within which lie the important gold mines of Sherbrooke, Fifteen-mile Stream, Wine Harbor and Cochin's Hill. The whole area is generally rocky, studded with lakes, and for the most part barren, the inhabitants obtaining their living chiefly from the sea or from the mines. The land of the Gulf shore, on the contrary, is productive, well cultivated and thickly settled, and much greater variety prevails in the rock formations, Carboniferous, Devonian and pre-Cambrian being represented, similar in most respects to the strata, the limits of which have also been traced and described in the report for 1879–80.

To the Carboniferous, which occupies the coast from Blue Cape to Antigonish, belong the large deposits of excellent gypsum about Antigonish, Powquet, Tracadie and elsewhere; the limestone largely used for railway bridges and buildings—as in St. Wiman's Cathedral, at Antigonish—and also for making lime; clays used in the manufacture of bricks; and the small unimportant coal seam of Powquet Harbor. A small quantity of copper ore has also been obtained, mixed with coal, in the bark of fossil trees, as at Powquet Forks; at other times, at the contact of a Carboniferous limestone with conglomerate, mixed with both, in the form of purple pyrites or copper glance, as described in previous reports on Cape Breton. Deposits of this nature have been mined at Brierly Brook, Addington Forks and St. Joseph. Many of the limestones of the Ohio River contain traces of galena in addition to copper, and have been mined, but without profit.

The Devonian rocks which underlie the Carboniferous to the southward contain specular iron ores, similar to those of Salmon River, Boylston, Ragged Head and other places already described, which have been worked at Caledonia mills, Springfield and elsewhere. The copper ores of Lochaber and Polson's Lake are also of Devonian age, and appear to be associated with dykes of basic intrusive rock, which are numerous throughout the Devonian area. No work has been done at these mines lately.

Few economic minerals have been found in the pre-Cambrian rocks which occupy small bosses on the eastern shore of Antigonish Harbor, and a large area in the Kippoch Mountain, which extends to the East River, in Pictou county. Below the Ohio cross roads is an irregular vein carrying a considerable quantity of yellow copper ore.

Field work was begun on the 13th of May and terminated on the 1st of December.

CHEMICAL, MINERALOGICAL AND LITHOLOGICAL SECTIONS.

Mr. Hoffmann's report on these sections is as follows :—

"The work carried out in the laboratory during the year was almost exclusively of a practical character.

"The investigation referred to in the report of 1881–82–83 in regard to the characters and economic values of the coals and lignites of the North-West was completed [see Report of Progress 1882-83-84 Report M]. A number of stones were examined and reported on with reference to their durability as building materials. Numerous gold and silver assays, including an extensive series of specimens from the Lake of the Woods gold mining district, were made; also analyses of copper, iron and other ores, as well as a variety of miscellaneous examinations. Two hundred and ninety-three mineral specimens have been received—brought or sent—either for identification or for information in regard to their economic value. Apart from the time devoted to personal interviews in this connection, it further entailed the writing of 103 letters, which, in a good many instances, partook of the nature of reports.

"During the year Mr. F. D. Adams acted in the capacity of assistant chemist for seven months, and four months were devoted by him to field work. *

"In the mineralogical section of the museum very marked progress and improvement may be reported. Valuable additions have been made to the collection. Mr. Broadbent devoted himself continuously and most assiduously to the work of labelling the specimens, with most satisfactory results. To complete the work, a large amount of labor is, however, yet required.

"Mr. C. Willimott, assisted by Mr. H. P. Brumell, has arranged, labelled, catalogued and dispatched thirty-one collections, comprising 2,813 specimens of minerals and rocks for which application had been made by various educational institutions. He also, during the winter, prepared a report of the examinations he made the previous season. This is published in the annual volume of Survey reports for 1882–83–84. During the summer he again visited, with Mr. Brumell, the township of Wakefield, Quebec, and also the townships of Kingston, Thurlow, East and West York, Caledon and Barton, in Ontario, for the purpose of collecting specimens and obtaining information in regard to certain mining industries. These visits resulted in large and very desirable additions to the mineralogical section of the museum, to which also a number of accessions were made by presentation."

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* This work has already been referred to under the head of surveys.

Biological Section.

In this section Mr. Whiteaves reports that the first part of the third volume of the "Palæozoic Fossils" of Canada was published in March. It contains forty-four pages of text, and is illustrated by eight octavo lithographic plates and four woodcuts. The third part of the first volume of Canadian "Mesozoic Fossils" was published in April. It consists of seventy-two pages of letterpress, with twelve octavo lithographic plates. A considerable portion of the MSS. of the second part of the third volume of "Palæozoic Fossils" was written, and many of the drawings required to illustrate it was made. The fourth and concluding part of the first volume of "Mesozoic Fossils" was also in course of preparation during the year 1884.

At the meeting of the Royal Society of Canada, in May, two papers were read before the Geological section, viz., one a "description of a new ammonite from the Cretaceous rocks of Fort St. John, on the Peace River," the other "on a decapod crustacean from the Cretaceous shales at Highwood River, Alberta."

On the occasion of the meeting of the British Association in Montreal, and at the request of the committee of the Geological section, a short verbal communication on the present state of our knowledge of the Cambro-Silurian rocks of Manitoba and Keewatin was made to the section, in connection with a paper by Mr. J. Hoyes Panton. This communication was based exclusively upon explorations and collections made by various officers of the Survey, from 1870 to 1883 inclusive.

In anticipation of the visit or visits of members of the British Association and their friends to Ottawa, every effort was made to get this section of the museum into as perfect order as possible, and the fine collection of Canadian aboriginal antiquities, recently acquired from Mr. C. A. Hirschfelder, was temporarily arranged in the mapping room. As the museum work of the year, however, was done conjointly with Messrs. Weston and Ami, it will be described more in detail in connection with the work of the latter. An unusual number of specialists, from Europe and the United States, visited the museum during August and September, and some time was spent in endeavoring to explain the specimens in which these gentlemen were most interested. During the absence of the Director, on field work, in September and October, the duties of Acting Director devolved upon Mr. Whiteaves.

Collections of fossils from the Hudson River formation at Oakville, Ont., from the Devonian and Cretaceous rocks of the Athabasca River, and from the Silurian and Cambro-Silurian of Back Bay and other localities in New Brunswick, were examined and reported on, for

Messrs. Lawson, Dr. R. Bell and Prof. L. W. Bailey. The recent invertebrates obtained by Dr. Bell at Hudson's Bay, were examined, and most of the species identified. A list of the latter was prepared for publication in Dr. Bell's report. In the zoological collection, twenty-five species of Canadian mammals and fifty of Canadian birds were named and labelled.

The study, which was commenced in 1883, of the large series of Laramie and Cretaceous fossils, now in the museum, from the Bow and Belly Rivers district, was continued, and the additional collections made in 1884, from the same region and rocks, by Messrs. R. G. McConnell, J. B. Tyrrell and T. C. Weston, were examined, and most of the species determined. A portion of the MSS. of a report on the whole of these fossils was written, and about half of the necessary drawings were made.

The extensive collections of Cambro-Silurian fossils made in 1884 by Messrs. T. C. Weston and J. M. Macoun, at various localities in the valley of the Red River, Manitoba, on the west coast of Lake Winnipeg, and in the islands adjacent thereto, consisting of nearly 1,000 specimens, were subjected to a preliminary examination.

From the 1st of January to the 20th of May, Mr. Weston's time was employed in re-arranging and labelling specimens, in general museum work, and in the preparation of a number of microscopic sections of rocks collected by various members of the staff. From the 21st of May to the 10th of September he was occupied in the field. The localities first visited were Swift Current Creek, Irvine Coulée and the Saskatchewan coal mines. The rock exposures along the west shore of Lake Winnipeg were afterwards carefully examined, from Cat Head to the mouth of the River, and on Punk, Deer and other islands in the lake, as were also the Cambro-Silurian limestone of East Selkirk and Lower Fort Garry. Large collections were made at most of the localities visited, not only of fossils, but also of hand specimens of rocks, clays, silts, concretions, &c. After his return to Ottawa, on the 10th of September, Mr. Weston went to Quebec and made a collection of fossils from the Cambro-Silurian slates of the Citadel Hill, the first fossils of any importance that had been collected at that locality. He also went to the best *Eozoon* locality and made a collection of specimens for distribution. The following is an approximate estimate of the number of fossils collected by Mr. Weston during the year:—

From the Laramie and Cretaceous Formations of Alberta, N.W.T.

40 Portions of jaw bones.
49 Teeth—mammalian and reptilian.
46 Vertebræ.
216 Portions of limb-bones.
20 Rib and other bones.

371

60 Cretaceous mollusca from three miles north of Ross Coulée.

From the Cambro-Silurian Rocks of Manitoba.

394 Fossils from Stony Mountain.
56 " " East Selkirk.
84 " " Lower Fort Garry.
384 " " various localities on west coast of Lake Winnipeg, and on the islands near that coast.

918

From the Lévis and Hudson River Formations—Point Lévis and Quebec.

40 Graptolites from Point Lévis.
50 " from the Cove Fields, Citadel Hill, Quebec.

Mr. Weston has also taken about forty photographs of geological sections, &c., in the North-west Territory.

Mr. H. M. Ami was occupied chiefly in the re-classification and re-labelling of the fossils in the museum, under the supervision of Mr. Whiteaves. The whole of the species from the Hudson River formation, from the Cambro-Silurian rocks of Manitoba and Keewatin, from the Guelph formation, from the Oriskany of western Ontario and the Lower Devonian of Campbellton and the Cascapedia, N.B., from the Hamilton formation, from the Upper Devonian of Quebec and New Brunswick, from the Neocomian of British Columbia and the Gault of the Queen Charlotte Islands; also the fossil plants of the Upper Cretaceous of the Nanaimo and Comox coal fields of Vancouver Island, and of Peace River, were re-arranged, and in all cases re-labelled. A commencement was also made of a systematic re-arrangement of the Laramie and Miocene plants and insects of the Souris, Nicola and Similkameen Rivers, N.W.T., and British Columbia, and of the Devonian fossils of the Corniferous formation of western Ontario.

With a view to determining the exact geological horizon of the rocks in which they are found, the following collections of fossils was examined by Mr. Ami, under Mr. Whiteaves' supervision. The species were determined as far as possible, and lists of them prepared:—

A. R. C. Selwyn:—
Fossils from a Black River limestone outlier forming islands in Lake Nipissing.

R. W. Ells and Assistants:—
Fossils from various localities in the Devonian and Silurian rocks of the Gaspé peninsula.

L. W. Bailey and Assistants:—
Fossils from the Silurian and Cambro-Silurian of Carleton, Charlotte and Victoria counties, New Brunswick, with several collections previously made at those localities by C. Robb, G. F. Matthew and T. C. Weston; also fossils from the Eastern Townships and the neighborhood of the city of Quebec, collected by T. C. Weston.

Named collections of fossils were also sent to educational institutions during the year, and a few small ones to private collectors, in exchange for other specimens. About twenty boxes of specimens in the basement have been opened and a number of types found that had been mislaid many years ago. The number of specimens and of species of fossils exhibited in the cases in the upper flat of the museum were found to be upwards of 11,000 specimens and about 3,000 species. Of these, fully two-thirds, or about 2,000 species, have been re-arranged and re-labelled since 1882. Records of donations and additions to this branch of the museum have been regularly kept and the palæontological and zoological publications issued during the year have been distributed.

Mr. S. Herring was engaged as taxidermist to the Survey on the 1st of February last, and since that date he has been occupied in mounting specimens for the museum.

In addition to the fossils already mentioned as having been collected by Mr. Weston, the following collections were received during the year from members of the staff:—

G. M. Dawson:—
One hundred and fifty specimens of palæozoic fossils from the Rocky Mountains.

L. W. Bailey :—

Seventy species of Cambrian fossils from Stanford Brook, St. John county, New Brunswick, identified and named by G. F. Mathew, St. John, N.B.

R. G. McConnell :—

A number of Cretaceous invertebrates from the Wood Mountain region, district of Assiniboia.

J. B. Tyrrell :—

About 400 specimens of plants, invertebrates and vertebrates (including the skull of a dinosaur), from the Laramie and Cretaceous rocks of the Red Deer and Battle River districts.

A. C. Lawson :—

Thirty specimens of stone and copper implements, pottery, &c., from ancient mounds at the confluence of Little Lake and Rainy River.

R. Bell :—

An interesting series of marine invertebrates, insects, birds, mammals and fishes from Hudson's Bay. Seven mammals. twenty birds, two fishes and one fossil bone having been given him by P. W. Matthews, M. R. C. P., (Lond.), L. R. C. S., (Edin.)

A considerable number of specimens were also added to this section of the museum by presentation and a few acquired by purchase, the latter including an important collection of Indian relics from Mr. C. A. Hirschfelder.

Botanical Work.

This work is reported on, by Professor Macoun, as follows :—

"On the 1st of December, 1883, my assistant, J. M. Macoun, commenced, in accordance with your instructions, to label, mount and arrange the herbarium. This work, involving the writing of 6,500 labels, was completed, and the greater part of the polypetalæ registered before the 20th of May, when he left with Mr. Weston for the North-west. After his return, on the 25th September, he mounted, ticketed and arranged in the herbarium, 1,118 sheets of specimens, which are chiefly part of my own and his collections during the past summer.

These, at commercial rates, are worth $333·50. Specimens of 800 species have also been sent to various institutions and individuals. Besides necessary correspondence, I examined and named all the collections made by the field parties in 1883, and also prepared the second part of the Catalogue of Canadian Plants—the Gamopetalæ. In the spring you expressed a wish that I should examine the country lying north of Lake Superior, and along the line of the Canadian Pacific railway. I therefore visited the country west of Lake Nipissing in the end of May, and early in June, proceeded to Lake Superior, where the country from Port Arthur to Dog Lake, north of Michipicoten, was examined. The Nipigon River was ascended, and Lake Nipigon circumnavigated. These excursions have afforded data sufficient to show the character of the climate and the botanical features of the region. In August I returned to Ottawa, and after attending the meeting of the British Association in Montreal, the members of the Biological section proceeding to the Rocky Mountains, asked permission for me to accompany them. After my return, on the 21st of September, I was engaged correcting the proofs of the catalogue prepared last winter. It contains 202 pages, royal 8vo. The collections made during the past summer are now being examined and named. The examination of Dr. Bell's collection, from the shores of Labrador and Hudson's Straits and Bay, was completed, and the list of species prepared to accompany his report.

Some time was devoted during the year to collecting good specimens of Canadian woods, and there were in the museum at the close of 1884—280 sections, representing 115 species of our useful forest trees. An extended catalogue of the trees and shrubs of the North-west was made out and furnished, by request, to the Minister of Agriculture, Manitoba, for publication in the report of his Department.

LIBRARY.

The Librarian, Dr. Thorburn, reports that during the year 1884, from 1st January to 31st December, 5,471 copies of the Geological Survey publications were distributed. Of these, 2,729 were distributed in Canada, the remainder—2,742—were sent to scientific and literary institutions, and individuals in America, Europe, India, Japan and Australia.

Three hundred and sixty-five French copies of the Report of Progress were distributed during the year.

A larger number of these would have been distributed had the printing not been delayed. English copies were, in consequence, sent to a

number of individuals and societies who would otherwise have received French ones.

Six hundred and forty publications, including books, transactions, memoirs, periodicals, pamphlets and maps were received as exchanges.

Fifty volumes have been added to the library by purchase and forty-three magazines and periodicals have been subscribed for during the year.

Three hundred and ninety-three volumes have been bound since the 31st of December, 1883,

The catalogue has been completed, but it is considered unnecessary to incur the cost of printing it. And for future reference in the library, it is proposed to make a card catalogue, such as is now used in most well arranged libraries.

VISITORS.

The number of visitors to the Museum in 1884 was 13,946.

STAFF, APPROPRIATION, EXPENDITURE AND CORRESPONDENCE.

There have been no changes in the permanent staff during the year. It consists of twenty-five persons, including the Director.

The position of artist is vacant since the retirement of Mr. A. H. Foord, the drawing having since been done by Mr. L. H. Lambe, of Montreal, and Mr. J. Watts, R.C.A., of Ottawa.

The appropriations for the fiscal year ended 30th June, 1884, were :—

Civil list salaries	$31,604.00
Contingencies	60,000.00
Total	$91,604.00

against which the expenditure for the Geological and Natural History and the maintenance of the museum is charged.

The expenditure may be summarized under the divisions named as follows:—

Pay-list salaries	$30,504.00
Wages of temporary employees	13,280.70
Exploration and survey, including travelling charges, purchase of horses and equipment	25,218.40
Printing and lithography	10,381.60
Purchase of specimens	1,496.15
Purchase of books and instruments	1,367.43
Chemicals and laboratory apparatus	188.39
Stationery	663.04
Fuel	106.86
Incidental and other expenses, including museum and other office fittings	3,685.80
	$86,892.37

The correspondence of the branch shows 2,611 letters sent, and 3,432 received.

The following remarks relating to mineral statistics and mines and the economic bearing of the work of the survey, which were appended to the survey report of 1884, may appropiately be reproduced here:—

As the subject of the collection and publication, by the Survey of statistics of mines and mineral products has of late been much discussed in the Press and elsewhere, and much misconception appears to have arisen respecting it, I may be permitted to refer to my views and action in this connection—the first, expressed as follows in my summary report to the minister, dated 2nd May, 1870, and the second, shown by the results as published in the Geological Report for 1871-72, pages 146 to 154.

Extract from Report dated May, 1880.

"In view of the importance and usefulness of mining records, and of complete and accurate statistics of mineral produce, it is thought desirable to endeavor, in future, to publish yearly, with the reports of the Geological Survey, a return of the mineral production of the Dominion. With this object in view, the annexed circular and blank form have been issued, and copies of it have been sent to all persons who, it has been ascertained, are actively engaged in mining, or in raising or manufacturing mineral products, and whose addresses were known. In circulating the printed form, either personal or written application has, in most cases, also been made to have the information asked for under the respective heads given in as complete a form as possible, and the object of the inquiry has, at the same time, been more fully explained. No great success can be expected at first; neither is it likely that the replies received will be of such a nature as to afford the requisite material for the compilation of as complete a statistical return as could be desired. The precise object of the inquiry will have to be familiarized, and its probable utility more generally understood and appreciated. On the whole, however, the results already obtained are very encouraging, and I have no doubt that by degrees a large amount of valuable information relating to the mineral produce of the Dominion will be collected.

"Mr. Edward Hartley has issued ninety-seven circulars, with explanatory letters. Eleven only of these have been returned filled up, in most cases, very satisfactorily. He has also received fifteen letters, acknowledging the circular, and promising to return the form filled in with the information asked for. Two hundred copies of the circulars

have been sent to the Honorable Robert Robertson, Commissioner of Mines and Public Works in Nova Scotia, who has kindly promised his assistance in distributing them there, and undertakes to see that they are put in the hands of every person engaged in mining, connected with his department, who would be likely to make any use of them.

"Professor R. Bell has sent 169 circulars to eighty-four persons in Ontario and Quebec, some of whom have undertaken to distribute the duplicates sent to them to mine-owners in their respective districts, whose addresses were not known at the Geological Survey office. Of these, only fifteen have yet been returned; they are filled up very satisfactorily. Twenty more have been acknowledged, and the information promised. Sectional drawings of two mines have been sent with the returns, showing the nature of the deposit and the extent of the working.

"The scheme, so far, appears to meet with general approval, and no one to whom application has been made has declined to give the desired information.

Extract from Report, 1871-72.

"The following tables, compiled by Mr. C. Robb, exhibit in a concise form the results of mining operations during the last three years throughout the Dominion of Canada and British American Provinces. They have been compiled chiefly from information obtained by the officers of the Geological Survey, under the arrangement specified in Mr. Selwyn's Summary Report, addressed to the Legislature, and dated 2nd May, 1870, pp. 13 and 14; and partly from the reports of the Commissioner of Mines for Nova Scotia, supplemented by other authentic sources of information. In some cases, in order to render the tables more complete and uniform, it has been deemed necessary to fill up some of the items by estimating according to the compiler's best judgment. In such cases the figures are marked by an asterisk. It is to be regretted that the returns are so incomplete as to render such an expedient necessary; and it is hoped that, when the importance and value of such records are duly recognized, the parties more immediately interested will give their cordial co-operation. These tables comprise the records only of such mines as have been in operation during the whole or any part of the three years referred to; and in some instances, where it has been impossible to obtain any information, all notice has necessarily been omitted. In the column indicating the year, the brackets denote that the "aggregate" production, number of men, &c. for each year, of all the mines of the class referred to, is recorded."

It may naturally be asked why this work was not continued, and on

this point I may say the reasons were numerous, chief among them, however, being, that after the third year but a few of the circulars issued were returned, while at the same time I was instructed to direct my own attention and that of the staff to the exploration of the North-west and British Columbia. That the development of mines and economic minerals in the Dominion generally, however, has not at any time been, as has been stated, "entirely neglected," or "received no attention whatever," is sufficiently proved by the following list of reports published by the Survey, and which relate exclusively to this subject:—

SELWYN. Notes and Observations on the Gold Fields of Quebec and Nova Scotia.

BROWNE On the Phosphate of Lime and Mica found in North and South Burgess.

RICHARDSON. On the Coal Fields of Vancouver Island.

VENNOR. On Geology of Leeds, Frontenac, &c., with notes of Gold of Marmora, &c.

ROBB. Mining and Mineral Statistics.

SELWYN. On the Acadia Iron Ore Deposits of Londonderry.

RICHARDSON. On the Coal Fields of Vancouver and Queen Charlotte Islands.

VENNOR. On Counties of Frontenac, Leeds, &c., with plan of Dalhousie Mine.

ELLS. Operations in Boring for Coal, New Brunswick.

ROBB. On Coal Mines of Sydney, C.B.

HARRINGTON. On Samples of Brick Clay from Manitoba.

HARRINGTON (Appendix to Selwyn). On Western Coals.

HOFFMANN (Appendix to Bell). On Lignites.

VENNOR. On Frontenac, Leeds, &c. Notes on Plumbago, Apatite, &c.

BARLOW. Springhill Coal Field.

MCOUAT. On a portion of the Cumberland Coal Field.

HARRINGTON. On the Iron Ores of Canada and their development.

ELLS. Second Report on Borings for Coals in New Brunswick.

ELLS. On Iron Ore Deposits of Carleton County, New Brunswick.

VENNOR. On Frontenac, Lanark, &c., with notes on some of the Economic Minerals of Ontario.

ROBB. On Explorations, &c., with Table of Sections of Measures in Sydney Coal Field.

SMITH. On History and Statistics of Canadian Salt.

ELLS. On Boring Operations in the North-west.

BARLOW. On Progress of Survey of Coal Fields of Cumberland County, Nova Scotia.

DAWSON. Mines and Minerals of Economic Value in British Columbia.

RICHARDSON. On Coal Fields of Nanaimo, Comox, &c.

HUNT. On Goderich Salt Region.

VENNOR. On Renfrew, Pontiac, &c., with additional notes on Iron, Apatite, Plumbago, &c., of Ottawa County.

BAILY AND ELLS. On L. Carboniferous Belt of Albert and Westmorland Counties including the Albert Shales.

HOFFMANN. On Canadian Graphite.

HARRINGTON. Report on Minerals of some of the Apatite-bearing Veins of Ottawa County.

SELWYN. Report on Boring Operations in the Souris Valley.

DAWSON (Appendix to Selwyn). On Lignite Tertiary Formation from the Souris River to the 108th Meridian.

DAWSON. Preliminary Report on Bow and Belly River region, with special reference to the Coal Deposits.

WILLIMOTT. Notes on some of the Mines of the Province of Quebec.

Special Reports (Published Separately).

Descriptive Catalogue of Economic Minerals of Canada, &c., Philadelphia Exhibition, 1876.

Catalogue des Minéreaux Économiques du Canada, Exposition Universelle, Paris, 1878.

Preliminary Note on Geology of Bow and Belly Rivers District, with special reference to Coal Deposits (published separately), 1882.

General Note on Mines and Minerals of Economic Value of British Columbia. (Published separately. Also first printed in Canadian Pacific Railway Report, 1877.)

The above enumeration shows a total of thirty-seven reports (without counting two, which were also printed as special reports) making known in their titles their special bearing on mines, mineral deposits and statistics of mineral production.

Besides the above it will be found that in almost every report published in each of the twelve volumes issued during the past fourteen years, the closing pages are devoted specially to an enumeration and statement of all the economic minerals observed, or reported to occur, in the districts to which the report itself relates. This is precisely the same system as was adopted in this connection by my predecessor, Sir W. E. Logan.

Without, however, now further referring to the past, we may perhaps offer some suggestions for the prosecution of this work in the future, and I may say that after carefully considering the matter in all its aspects, I am led to the belief that the system I originally adopted, namely, that of issuing a circular, with questions to be answered on a form printed for this purpose, and when convenient or considered necessary, to be accompanied by personal application on the ground, is that which is most likely to afford the desired result. There are two gentlemen, trained mining engineers, now employed on the Survey, to whom the work of issuing, collecting and compiling the returns might be entrusted, and who might also each year visit and critically examine and report on one or two mining districts. In this way, every mining district in the country would be visited at intervals of one or two years, unless some special development called for more frequent examination.

At present the chief mining developments are in the Provinces of Nova Scotia, Quebec and British Columbia, and in each of these Provinces the Local Government employs a mining inspector or engineer, who collects statistics and reports on the mines of the province.

It would not, therefore, seem desirable or necessary that the work should also be done in these provinces by the Geological Survey, but with the co-operation and consent of the provincial authorities the results obtained by their officers might be incorporated in the general statement issued annually by the Geological Survey, and thus gain wider publicity.

So far as the special examination of mining districts is concerned, a commencement was already made in 1883 and continued in 1884, the districts examined being:—In 1883, the Lake of the Woods gold region and the phosphate region in the townships of Wakefield and Templeton; and in 1884, the Marmora gold and iron bearing region, and the mining region around the north shore of Lake Superior; also some of the mines in the Province of Quebec.

If the scheme now proposed is carried out, no further assistance would be required, but the two gentlemen named—Messrs. E. Coste and E. D. Ingall—should be appointed on the permanent staff, with the title of mining geologists.

1885.

The summary reports of the officers in charge of the field parties show that in 1885, the work, as in former years, has been prosecuted over portions of every province and territory in the Dominion, from Nova Scotia to the west coast of Vancouver Island. Valuable information, both as regards the topography and the geology, has been secured, and a number of important additions to the collections in the museum has been made, both by gift and by purchase, as well as by the efforts of the officers of the Survey. These are referred to in detail further on, under the mineralogical and biological sections.

In regard to the survey and exploration of Lake Mistassini, referred to in my last summary report, I regret to say that my anticipations respecting it, as then stated, were subsequently verified. On the 2nd February, Mr. Low left the party encamped on the lake shore, and came out on snow-shoes to Lake St. John, whence he proceeded to Ottawa, arriving there on the 3rd March. From his report I considered it expedient that he should at once return, and take charge of the survey. He accordingly left Ottawa on the 28th of March, accompanied by J. M. Macoun, as assistant, and reached Lake St. John on the 5th of April. Thence they proceeded on snowshoes to Lake Mistassini. Owing to the lateness of the season, however, travelling at night became necessary, and with much difficulty and considerable hardship they reached the lake on the 28th of April. Up to that time no attempt had been made to ascertain the size of the lake or to survey its shores. A summary statement of the work of Mr. Low is given on a subsequent page. Detailed reports relating to some of the work of 1884, referred to in my last summary report, which will embody the work of two seasons, are now in the press, while others, including that of the Lake Mistassini expedition, are being prepared, and all will, it is hoped, be ready for publication during the winter.

It is, proposed, in future, to issue a certain number of copies of each report separately, and as soon as they are printed, while the remainder of the edition will be issued later, as heretofore, in one volume, containing all the reports published during the year from January to December. For economicial reasons, this course has not hitherto been adopted, but it will, it is hoped, prove more convenient.

In addition to the work of editing reports, &c., and general superintendence, much of my time and attention during the past year has been occupied with correspondence and other matters connected with the Antwerp exhibition and the Colonial Indian exhibition.

EXPLORATIONS AND SURVEYS.

My own work in the field during the past summer, comprised examinations, partly alone and partly in company with Messrs. Weston, Ells, Coste and Ingall. From the 20th June to the 17th July, in the vicinity of Quebec and on the Island of Orleans; from the 17th to the 31st July, around Massawippi and Memphremagog Lake and in vicinity of Sherbrooke. On the 8th of August I left for Port Arthur, and accompanied Mr. Coste to the Slate Islands.

On the 22nd, the "Zenith Zinc Mine" was visited and examined. It is situated about twelve miles inland to the north of McKay's Harbor, on the Canadian Pacific Railway. The route to it is by a series of lakes and portages on the course of the White Sand River. The deposit is an exceedingly interesting one, and when more easily accessible may prove of considerable value. A short report on it was given to the owners. Already some 400 or 500 tons of ore have been raised, but there being at present no available road from the mine to the lake shore, it cannot be sent to market.

On the 27th of August, while making examinations along the line of the Canadian Pacific Railway, I met with an accident, which prevented continuance of active field work till the 7th of October, when I left Winnipeg, accompanied by Mr. C. Moberly, to examine some outcrops of Cretaceous rocks on the Assiniboine River, in Township 8, Range 11, Section 36, where strong indications of petroleum were reported to occur, and which had been first observed while an attempt was being made to open a freestone quarry. The outcroop extends along the bank of the river for about 500 yards, and consists of beds of highly fossiliferous sandy limestones, brown freestone, and dark—almost black—soft shales. The sandstone and limestone, when broken or struck, emit a strong odor of petroleum, but whether it exists here in quantity or not can only be ascertained by boring. It might be worth while to test the question in this manner, as the geological features are not unlike those on the Athabasca, and Clearwater Rivers, where both lignite-coal and petroleum occur, the latter impregnating a great thickness of Cretaceous sand-rock and also forming considerable deposits on the surface of the ground.

On returning east I again spent a few days at Port Arthur, and accompanied by Mr. Ingall, visited and cursorily examined the Rabbit and Silver Mountain mines, where magnificent specimens of silver ore have been obtained by the original prospectors, some of which are, through the kindness of Mr. Keefer, now in the museum of the Survey. The geological structure and relations at these mines are,

so far as I can judge, precisely similar to those observed at some of the older mines around Thunder Bay. These latter, have, however, been successively abandoned, presumably, because they proved unprofitable; but whether this arose from mismanagement, lack of enterprise, or some other cause, it is not easy now to determine, and we can only hope that a similar result will not attend those prospects now being developed in the district referred to. Mr. Ingall is preparing a detailed report on this district, based on his examinations and surveys made during the seasons of 1884 and 1885. The veins are well defined, and have a most promising appearance, and there seems no reason whatever why they should not continue to yield ore in depth as rich as any that has been found on the outcrops.

British Columbia.

Dr. G. M. Dawson has been engaged during the past summer in the geological exploration of a portion of the coast of British Columbia. The work so far carried out by the survey on the seaboard of this province, has been comparatively limited. The late Mr. James Richardson visited and cursorily examined a number of points, but his detailed and connected surveys were practically confined to the part of the Cretaceous coal-bearing rocks which extend south-eastward from Comox. Dr. Dawson had previously (in 1878) explored and surveyed the greater part of the coast-line of the Queen Charlotte Islands, and in the same year carried out some reconnaisance work in the northern part of Vancouver Island; but this, being of a preliminary character, and incomplete, was not published in detail. The exploration of the past season was undertaken with a view of adding to and extending the area of this work with special reference to the definition of the areas of coal-bearing rocks known to exist in the region in question. Dr. Dawson's summary report on the operations of the season is as follows:—

"Accompanied by Mr. D. B. Dowling, as assistant, I left Ottawa on the 3rd of June, arriving in Victoria on the 11th. It had been intended, if found practicable, to hire a steam-launch or small schooner with auxiliary steam-power; the experience of previous years having shown that much loss of time was likely to occur if dependence had to be placed on a sailing craft for locomotion, while work carried on by boat or canoe along shore entails frequent long return journeys to the few points at which supplies can be obtained on this coast. It was, however, found that no suitable craft with steam-power was available in Victoria within the necessary limitations of expenditure, and after ex-

hausting enquiries in this direction, the schooner "Carolena" (32 tons) was eventually chartered for use during the season. We sailed from Victoria on the 21st June, some days having been necessarily employed in procuring equipment for an absence of several months. Two days were also devoted, before leaving, to the examination of a deposit of iron ore at Sooke, near Victoria.

"The examination of the coast was begun at Comox, where Mr. Richardson's work had terminated, and the Cretaceous coal-bearing rocks were traced thence along the coast of Vancouver Island for about thirty miles. These rocks were at this point—a short distance north of Cape Mudge—found to be replaced on the shore by an older trappean series on which they rest unconformably, and it would appear from information received from timber explorers, and as the result of our subsequent examination, that the continuation of the Cretaceous trough or basin of the Comox region here trends inland, having a breadth of several miles on the Campbell River, and, very probably, running through behind the ranges which border the coast as far as the head-waters of the Salmon River.

"Having examined the shores of Discovery Passage as far as Seymour Narrows, it became important to ascertain whether there was any recurrence of the coal-bearing rocks of the Comox basin on the north-eastern shores of the Gulf of Georgia. These, together with Malaspina Inlet and both shores of Malaspina Strait as far south-eastward as the entrance to Jarvis Inlet, were next systematically explored—the number of islands and intricacy in outline of the coast, rendering it necessary to traverse a great aggregate length of shore-line. Coal, which had been vaguely reported as occurring on Valdez Islands and in Malaspina Inlet, was not found in either place, nor were any outliers of the Cretaceous sandstones observed. It had also been supposed that the coal-bearing rocks might underlie Mary, Hernando, Savary, or Harwood Islands, the low, flat appearance of these favoring this view. It was, however, found that this appearance arises from the fact that these islands are composed of boulder-clay and other drift deposits, below which granite rocks come to the surface at a few places. A small area of sandstone rocks was, however, observed running inland from the north-east shore of Malaspina Strait, which is probably Cretaceous, but contains, so far as observed, no coal seams of any value. Several large lakes exist in this vicinity in the promontory between Desolation Sound and Jarvis Inlet. From one of these, a river of considerable size issues, and forms a fine fall within half a mile of the shore. The existence of these lakes is not indicated on the published charts, and though I had intended to devote some days to their exploration in the autumn, the project had eventually to be abandoned for lack of time.

"A portion of the north-eastern shore of Texada Island (forming the south-western side of Malaspina Strait) was next examined, including a locality at which openings had been made on copper ore, one at which marble had been quarried, and an important occurrence of iron ore. No work is now being prosecuted at any of these places, but there is in this vicinity an immense quantity of grey, banded and blotched marble, which passes into a nearly white variety, in some places. The marble is very well situated for quarrying, forming low cliffs along the shore for several miles. Later in the season the whole remaining shore of Texada Island, with that of Lasqueti and neighboring islands, was traversed, and the iron mine near Gillies Bay visited. To avoid reverting to this district, it may be stated that one locality of Cretaceous rocks, in addition to those indicated on Mr. Richardson's map, was discovered. It also appears probable, from the extent of low drift-covered country in that vicinity, that the Cretaceous area at Gillies Bay may be somewhat larger than shown on the map, and it may some day be worth while to bore either at this place or on Sangster Island, in order to ascertain definitely whether any coal seams occur in these small borders of the sandstone series which have here escaped denudation.

"Beyond Seymour Narrows, the shores of Johnston and Broughton Straits, with portions of those of adjacent water-ways to the northward were examined and found to consist of granitic rocks, with areas of an overlying series, which is for the most part volcanic in origin, but which has been much altered, and is at least in part of Triassic age.

"From Alert Bay, while Mr. Dowling continued the examination of the coast, I made an excursion up the Nimpkish River to Nimpkish or Karmutsen Lake, and finding the lake to be very imperfectly represented on the map, made a survey of the entire shore-line with Massy's floating boat-log. Marble occurs in considerable quantity on the shores of the lake, but as the same stone is found much more conveniently situated for shipment at the head of Beaver Cove, where some blocks have already been quarried, it cannot be regarded as of immediate importance.

"The Cretaceous coal-bearing rocks which extend along the coast from Port McNeill to Fort Rupert—a distance of 16 miles—which had been cursorily inspected by me on the way back from the Queen Charlotte Islands in 1878, were now more closely examined. This area is that in which coal was first discovered in British Columbia, and worked to a small extent by the Hudson Bay Company, which, also, as far back as 1852, caused some borings to be sunk to a limited depth. Though work was abandoned here on the discovery of the Nanaimo deposits, and the seams so far discovered are not thick, the regularity and light degree of inclination of the rocks are such as to promise well for the

value of any thicker beds which may be found to exist, and it is very desirable that further intelligently directed boring operations should be undertaken. The low, level character of Malcolm Island, suggested that Cretaceous rocks, forming an extension of those of this area, might underlie it, and though its shores exhibit for the most part drift deposits only, the correctness of this supposition was established by Mr. Dowling having discovered, in a single locality, conglomerates of the Cretaceous series. This is of importance, as indicating a much wider spread of the possibly coal-bearing rocks than had previously been known in this region.

"In following the shores of Vancouver Island and those of Hope, Galiano, and the the islands of the Gordon group, numerous facts of interest, from a geological point of view, were ascertained; but no further Cretaceous areas were met with, except two of quite inconsiderable size in Hardy Bay. At Nawitti, on Hope Island, two Indians and a canoe were engaged, and with them I examined the northern extremity of Vancouver Island, round Cape Scott, and as far south as Quatsino, the schooner meeting us again at the last-named place. We were fortunately favored with very fine weather on this expedition, which rendered it possible to land at a greater number of points usually difficult of approach, on account of the heavy sea on this exposed coast. The rocks belong, for the most part, to the altered volcanic series before referred to, and include bands of shale and limestone holding *Monotis*. A small patch of Shasta Cretaceous, with its characteristic *Aucella*, was found on the north shore of Raft Cove.

"Some time was next spent in examination of Quatsino Sound, and particularly of that portion of it in the vicinity of Coal Harbor, where boring operations have lately been in progress. Cretaceous sandstones and shales characterize rather wide-spread areas in this region, and several coal seams are known, though none have so far been discovered of such thickness as to justify extensive mining operations. It is believed that the knowledge now gained of these rocks is such as to be of service in directing future exploratory operations in search of coal.

"On returning from Quatsino to the inner coast of the island, the archipelago of small islands forming the eastern end of Queen Charlotte Sound, and the north-east shore of the sound as far as Blunden Harbor, was examined, and the distribution of the various rock series mapped, but no extension of the Cretaceous was met with in this direction.

"On the return voyage to Victoria we stood across to Lasqueti Island, and leaving the schooner at anchor in False Bay, I made the examination of that and Texada Island previously referred to.

"The result of the season's work has in general terms thus been the examination of the main shores of Queen Charlotte Sound, those of

the northern extremity of Vancouver and adjacent islands and Quatsino Sound, together with all the main shore of the Gulf of Georgia which had not heretofore been geologically mapped, with the exception of that portion between Jarvis and Burrard Inlets. While it was impossible to traverse the shores of all the numerous inlets and fiords ramifying into the mainland, it was endeavored to make the work actually done so complete as to obviate the necessity of re-examination till such time as geological mapping of a much more minute character than any yet contemplated is undertaken. It must be understood, however, that the work as it now stands is of a strictly preliminary character. Having been provided with a schooner, and the means of examining the coast (which affords the most easily accessible and instructive geological sections), it was deemed best to postpone lengthened excursions inland, though traverses were made for several miles into the bush, in a number of places, for the purpose of ascertaining the width of the coal-bearing rocks. Much information of a general character as to possible routes, and nature of the country, was also obtained, such as to render it easy to lay out future work for the completion of any given part of the region, and to indicate which of these will be of the most importance in the near future.

"The present report is intended as a sketch merely of the operations of the summer. It may, however, be not inappropriate to add a few general observations on this part of the coast from an economic point of view. It is scarcely, I believe, yet realized what a large quantity of valuable timber Vancouver Island and the adjacent mainland are capable of yielding. That at the shore is generally more or less windshaken and gnarled, but a short distance inland, where the surface is at all level, fine trees are found in abundance, and the wide valleys of the mountainous districts almost invariably hold extensive and well-grown forests. Toward the northern end of the island the Douglas fir is not so common, being to some extent replaced by the hemlock, and two species of spruce. The cedar (*Thuya gigantia*) is, however, here abundant, and the white pine (*Pinus monticola*) is commonly met with down to the shores, while the yellow cypress (*Chamæcyparis Nootkatensis*), a mountain tree in the vicinity of Burrard Inlet, comes down to the sea-margin in the latitude of Blunden Harbor, and is found in some abundance a few hundred feet above the sea-level over the whole northern end of Vancouver Island.

"North of Seymour Narrows, though extensive low tracts occur, there can scarcely be said to be any land fitted for immediate agricultural occupation, most of the surface otherwise suited for this use being so densely wooded that it would scarcely pay at present to endeavor to clear it. The north coast of Vancouver Island, however, between

Nawitti and Cape Scott, might be utilized to support a considerable number of cattle, owing to the quantity of grass which there grows along the shore, and the less dense character of the forest; while, running across behind Cape Scott is an extensive lagoon not shown on the charts, with tracts of grassy marsh, now subject to overflow at high tides, but of which, I believe, several thousand acres might be reclaimed by dyking.

"The Indians of all this region derive an easy subsistence from the products of the sea, but with this exception, and that of a few salmon canneries, the fisheries of the entire coast may yet be considered as untouched. The dog-fish is now, however, beginning to be taken in considerable numbers, at a few points, for the manufacture of oil, and before the lapse of many years it is easy to predict that the many inlets and coves of the west and north coasts of Vancouver Island will be occupied by a numerous and hardy population of fishermen. As a first step towards this desirable event, it is much to be wished that some adequate and scientific investigation of the banks and fishing grounds of the coast should be undertaken. Off the west coast of the island, in the spring, considerable numbers of fur seals are annually taken, while a few skins of sea-otter are still obtained by the Indians. This extremely valuable fur-bearing animal appears, however, as the result of indiscriminate and persistent hunting, to be verging on extinction, and its pursuit is not only a dangerous, but a very uncertain one.

"In connection with the geological work of the season, a large number of illustrative rock specimens were obtained, some of which, representing stones likely to be of economic value for building purposes, are of such size as to afford dressed six-inch cubes. A small collection of fossil molluscs from the Shasta beds was made in Quatsino Sound, together with a number of Cretaceous fossil plants from other localities. About sixty photographs, illustrative of the character of the country, were taken, and meteorological observations, including the temperature of the sea-surface twice daily, were kept up during the season by Mr. Dowling. When circumstances rendered geological work impossible, some attention was given to dredging and the collection of natural history specimens. A large number of marine invertebrates, including twenty-two jars of collections in alcohol, together with forty-four skins of birds and mammals were thus obtained. A small collection of dried plants was also made.

"After my return to Victoria, about three weeks was devoted to work in connection with the representation of the province in the Colonial and Indian exhibition. Ottawa was reached on the 20th of November."

In the interior of British Columbia, Mr. Amos Bowman, assisted by Messrs. McEvoy, Voligny and Tuck, commenced the survey and investigation of the well-known placer mining region of Cariboo. This work was undertaken at the request and with the co-operation of the Provincial Government, and it is hoped it will be continued in the same manner during the ensuing season. Although the district has yielded, in the past twenty-five years, about thirty million dollars of gold so much geographical information had to be procured as a first step towards its delineation, that the Geological Survey has not been in position heretofore to effect more than a cursory examination towards this otherwise desirable work. The Government of British Columbia having thus removed the principal obstacle by meeting half the cost, the conduct of the joint work was placed in the hands of the Director of the Geological Survey, and the execution was entrusted to Mr. Amos Bowman, mining engineer. The field work lasted from July to October, and covered the principal gold-bearing country, an area of fifty by seventy-five miles. The instrumental work done, embraced, besides the work of the triangulation and latitude stations, the measurement of 255·5 miles of traverse of the roads and trails of the country with the wheel, supplemented by a still larger mileage of track surveys; resulting in thirty sheets of plotted surveys of the diggings on a detailed scale, and of the roads and trails on a smaller scale, to be embodied in the general map.

The quartz mining interest was (incidentally) investigated. In returning southward from the field of survey, a feasible route was sought, and found, through an agricultural country the entire distance, for a branch railway line connecting with the Canadian Pacific at Ashcroft. To complete the mapping of the mining region proper, comprising an area of 3,700 square miles, on a sufficiently large scale to be valuable to the miner, will require another season in the field. While during the past summer it was necessary to devote almost the entire time of the party to geographical and topographical work, it is intended next season to use this as a basis on which to work up the geological and mining aspects of the district.

North-west Territory.

Mr. McConnell, assisted by Mr. James White, was engaged during the past summer almost entirely in the Rocky Mountains.

The work consisted in examining geologically and making a topographic survey of that part of the range which lies between the Canadian Pacific railway and the North Saskatchewan River, from the watershed eastward to the plains in this region, embracing an area of

about 5,000 square miles. All the passes that were accessible, and the head-waters of all the principal streams, amongst which are the Red Deer, Sheep Creek and the Saskatchewan, were traversed, and the bordering mountain ranges were carefully triangulated. Before publishing the map of this area, which is now being prepared, the field work should be extended west to the Columbia and north to the Athabasca Pass. This would fully occupy two more seasons.

The mountains, east of the main watershed, in this portion of their length, consist of a number of parallel and very regular limestone ranges, striking north-west, and separated by wide valleys, which usually present areas of Mesozoic shales and sandstones holding occasional beds of good coal. The limestones belong, for the most part, to the Devonian and Carboniferous systems, and rarely contain so far as known, minerals of economic importance. The main watershed range and the mountains to the west of it, which are partly composed of older strata, and include areas of igneous rocks, appear to present a much more promising field for discoveries in this connection.

About two weeks in the latter part of the season was spent on the plains, collecting a few details which were required to complete the map of some 30,500 square miles of the district of Assiniboia.

The fossils collected are referred to on a subsequent page.

Mr. J. B. Tyrrell, assisted by Mr. E. H. Hamilton, continued the examination of the country north of the Bow River and south of the North Saskatchewan, including an area of about 27,000 square miles, lying between 110° and 115° west longitude.

After making a canoe traverse of the Battle River, from the Edmonton-Calgary trail to the trail from Fort Pitt to Sounding Lake, and an examination of part of the telegraph trail west of the 110th meridian, he examined the country around Sounding Lake and in and around the Neutral Hills, and, in passing, re-examined the conglomerates and associated beds in the Hand Hills. On the Battle River, coal seams varying from 3 feet to 4 feet 6 inches in thickness, were found to crop out along the banks for about 35 miles, from a short distance below Dried Meat Lake to the mouth of Paint Earth Creek. These seams hold about the same geological positions as those on the Bow River near Blackfoot Crossing.

Towards autumn, a moderately detailed investigation of the country in and along the edge of the foot-hills of the Rocky Mountains, was proceeded with, adding considerably to our knowledge of the mineral, timber and grazing wealth as well as to the geography of that portion of the district which is drained by the Red Deer and Clearwater Rivers between the 112th and the 115th degrees of longitude.

Mr. Tyrrell also visited the so-called petroleum claims, located on the east bank of the Red Deer, a short distance below the mouth of Tail Creek, and reports that after a careful examination no signs of the presence of petroleum could be detected.

The disturbances in the North-west during the past year rendered it impossible to commence field work sufficiently early in the season, the month of May and half of June having passed before anything could be done. However, about 20,000 miles have now been examined, and if the map is published of the size originally intended, a small area along the Saskatchewan alone remains to be explored. The topography of the southern and eastern portions of the district is now plotted on a sheet which is ready to be put into the hands of a draftsman to be reduced and prepared for the engraver. If this work is proceeded with at once, the map could be ready for publication in the early part of the winter of 1886-87.

The palæontological and natural history specimens collected by the party are referred to in the report on the biological section by Mr. Whiteaves.

ONTARIO.

Mr. A. C. Lawson was occupied during the season in western Ontario, assisted by Messrs. A. E. Barlow, W. H. Smith and Mr. C. S. Morton. The work embraced two divisions:—

1. The prosecution of additional topographical and geological surveys for the map of the Lake of the Woods.

2. The commencement of a detailed topographical and geological survey of Rainy Lake and the adjoining water-stretches. The first of these entailed several weeks geological work by Mr. Lawson, in the same field as last year, rendered necessary in the light of the results arrived at previously. While thus engaged Messrs. Barlow and Smith were detailed to make a careful micrometer and compass survey of Whitefish Bay, a large body of water filled with islands, hitherto unmapped, except from sketch survey by Dr. Bell, while Mr. Morton was entrusted with a similar survey of the bays and inlands of the Winnipeg River from Rat Portage to the northern limit of the sheet, near the Dalles.

After the completion of the Winnipeg River survey, and while Messrs. Barlow and Smith were yet engaged on Whitefish Bay, Mr. Lawson and Mr. Morton proceeded with a survey of the shore and islands lying between Falcon Island and Sabaskong Bay, over which it had been decided to extent the limits of the sheet, the details of the topography devolving upon Mr. Morton, while Mr. Lawson's attention was directed to the geological features of the country.

The survey of Whitefish Bay having been completed in the meantime, Messrs. Barlow and Smith carried their line across Sabaskong Bay, and proceeded to make a survey of the chain of lakes, rivers and portages that constitute the back canoe route between the Lake of the Woods and the North-west Bay of Rainy Lake. This work involved, besides the surveying of the topographical features, a careful examination of the rocks along this line of survey with the view to mapping their distribution. The continuation of the survey of the west end of Rainy Lake, was then proceeded with, and by the close of the season a continuous survey had been established between Rat Portage and Fort Frances, and the geological conditions of the country traversed from the mouth of Whitefish Bay to the United States boundary at the outlet of Rainy Lake, noted.

Mr. Lawson, having completed this work on the Lake of the Woods by the end of July, he and Mr. Morton were engaged for the remainder of the season on Rainy Lake. The former traversed the whole of the north shore of the lake to Kettle Falls, and for some distance beyond, into Nemeukan Lake, and made exploratory surveys of the Sand Island, of Turtle River, and of the Seine River to Sturgeon Falls, while the latter made a survey of the south shore of the lake and of the islands lying between Fort Frances and Kettle Falls. Mr. Lawson's attention was chiefly devoted to working out the structure of the rocks referred to the Huronian, a belt of which, with a width of more than 20 miles, traverses the lake. Many interesting geological features were brought to light and good indications were noted of the presence of mica, iron, molybdenum and other valuable minerals.

Mr. E. D. Ingall and party proceeded on 4th June last to Port Arthur to continue the work in the Lake Superior mining region, and returned to Ottawa 19th November.

The first half of the season was occupied in surveying along the coast line of the lake from Port Arthur towards the international boundary at Pigeon River, with the intention of mapping the details of this section of the Animikie series with a view to its sub-division, if possible.

The return to Port Arthur was made by way of the group of islands in the mouth of Thunder Bay, so as to visit and examine the mineral-bearing veins found on them, thus completing the examination of the chief mining ventures of the Lake Superior region.

During the latter half of the season, the party was engaged in making a contoured lithological map of the block of mining locations around the new finds of silver-bearing veins at Silver Mountain, intended to show the distribution of the different "country" rocks around this point, and the position of the veins and mining developments.

During the greater part of the season Mr. Ingall was assisted by Messrs. A. W. Hopkins and J. H. Moore.

The work connected with the preparation of the map and report of the Silver Mountain District is being proceeded with, and will probably take the greater part of the winter. When this is completed, the work of finishing the maps and report on the whole Lake Superior mining region will be continued.

Mr. E. Coste, assisted by Messrs. Vautelet and Mathewson for topographical work, was engaged during the months of June and the first half of July in continuing and extending the work of the previous season in Hastings, to the counties of Peterboro' and Victoria. In the second half of July, the Archæan rocks in the townships of Methuden, Burleigh and Harvey chiefly occupied his attention.

In July I received instructions to send Mr. Coste to make an examination of the Slate Islands in Lake Superior, after completing which he resumed his work in the townships of Lutterworth, Snowdon, Galway, Cavendish and Anstruther, and also made a careful examination of every locality in the area embraced by the map under preparation, where economic minerals were reported on good authority to have been found, or were being worked. The northern boundary of the fossiliferous (Cambro-Silurian) rocks is now delineated in all its details from Stocco Lake, in the township of Hungerford, to Head Lake, in the township of Digby, a distance, in a straight line, of eighty-five miles. There are in that distance twenty-five patches or outliers, some of which are five or six miles distant from the main mass, and form flat-topped hills, being from forty to seventy feet above the adjacent country, showing the enormous amount of denudation these strata have suffered since the close of the Cambro-Silurian period. Some of the beds afford an excellent yellowish-grey building stone, known as the "Dummer stone," and the lithographic beds of Madoc and Marmora are also met with further west in Harvey township.

Respecting the Archæan rocks in this region, the observations made by Mr. Coste this season tend to confirm the opinions he expressed as the result of those made last year, and he now states: "After carefully examining these crystalline rocks, I am of the opinion that folded together and perfectly conformable with gneisses and other rocks, which every one would class in the typical Laurentian, are often found rocks identical with those in Hastings, classed first by Vennor as the Hastings series, and which, as I stated last year, correspond with the typical Huronian of Logan. Therefore, it appears to me there is no distinction of group and period to be made between Huronian rocks and Laurentian rocks, and the former, so far as can now be determined, are only the upper portion of the latter, and appear to have been colored

differently on the maps only when they occupy large areas and show a series of great thickness."

As regards actual mining operations in this region, Mr. Coste reports as follows:—

"Very little was being done last summer in the region examined, two mines only being at work—the Canada Consolidated Gold Mine, near Marmora, and the Coe Hill Iron mine in Wollaston township. At the end of the season, work was started on a new deposit of magnetic iron ore, called the St. Charles. It is in the township of Tudor, within a mile of the Central Ontario Railway. I heard also of work having been resumed on the famous Richardson mine, where gold was first discovered in 1866, in the Madoc region.

"No ore was shipped from the Coe Hill mine from the beginning of July until the end of October, the ore extracted being piled up at the mine, where about 20,000 tons were waiting, I suppose, better market prices. The depths of the three shafts were, as under, in October last (1885), No. 1, 95 feet; No. 2, 130 feet; No. 3, 100 feet. At the Canada Consolidated Gold Mine, the large roaster erected last fall was in operation; also a refining furnace for the arsenic, and a new three-ton capacity chlorinator. The mine itself, unfortunately, had not been improved, no sinking or drifting having been done since last year, only some stoping work above the first level, sixty-five feet deep."

QUEBEC.

Mr. R. W. Ells, assisted by Mr. N. J. Giroux, was occupied during the summer in the examination of a large part of the country bounded on the north and west by the pre-Cambrian ridge, which extends from Memphramagog Lake north-eastward, and on the south and east by the States of Vermont, Maine and New Hampshire. In addition, a large part of the metamorphic or mineral-bearing belt was carefully investigated, and the structure and outlines of the interior Silurian basin, comprising a large portion of the townships of Wotton, Windsor, Brompton and Oxford were examined. The limits of the principal Silurian areas, in the counties of Stanstead, Compton and Beauce, were definitely fixed, as well as the outlines of the granitic masses included therein, as far as was practicable.

The intimate connection between the granites and the altered Silurian slates, in actual contact, proves that the age of these granites is, as in New Brunswick, probably Devonian. That they are extensive and probably continuous at certain depths not far from the surface is evidenced by the frequent outcrops, which often comprise large areas, of twelve to twenty square miles in extent, while others are in the

form of long dykes both along the lines of bedding of the slates and, in places, directly across the strike.

A large suite of rock specimens, illustrative of the various formations, was collected and several important corrections in the geological boundaries as laid down in the map of 1866 were made.

In all about 2,000 miles of roads were travelled, principally by buckboard.

The various mining centres of this portion of the township were visited. Among localities specially examined were:—

Iron deposits at Belvedere and Sherbrooke.

Copper mines of Capelton and the vicinity of Massawippi Lake.

Asbestos mines of Danville, Thetford, Black Lake and Belmina.

Silver mines of Roxboro' and Marlow.

Gold mines of Ditton, Ireland, Dudswell and the Chaudière.

Marble and lime works of Marbleton.

A traverse was also made along the line of the International Railway to a point ten miles east of the boundary into the State of Maine.

The most flourishing industry at present in this portion of the country appears to be asbestos mining. At Thetford, where the largest and most important operations are carried on, nearly 250 men are employed, with an annual output of about 1,100 tons, divided among four companies, viz., King Bros., the Boston Co., Johnston's Co., and Ward Bros.

At Black Lake three companies are at work, viz., Lionais', Hopper's and Frechette's, employing in all about 100 men, with a monthly output of not far from sixty tons ; a considerable amount of exploring work being also carried on.

At Belmina the force is small and the work up to the present mostly exploratory, but veins of workable size have been lately struck. At Thetford some of the veins have a width of from five to nearly seven inches, but the material in the large veins is not first quality, being off color. The work at all these places is prosecuted only during the summer season.

At Jeffrey's mine, Danville, about seventy men were employed, with an average weekly output of about fifteen tons, the quarrying being carried on all the year round.

The price of asbestos during the past year was, for No. 1, $75 to $80 No. 2, $50 ; No. 3, $10 ; the latter being largely used for paper stock.

Gold mining (washing) has been carried on in a small way on the Little Ditton for some years, the yield at intervals being very good. During the past summer four men only were employed in re-working and sluicing old tailings. Results unknown.

At Dudswell a shaft was sunk in drift near the foot of the Stoke

Mountain range, to a depth of 25 feet. The bed-rock was not reached. Gold was found at several points, and apparently well distributed. A ten-stamp mill was erected at this place by an American company, some months ago, with the apparent intention of crushing and washing the drift gravel, much of which consists of quartz schist, said to carry a small quantity of gold, but nothing of consequence has been done since its erection, the mill being run for a very short time.

On the Chaudière, the St. Onge Mining Company have at last succeeded in reaching the bed-rock at the bottom of a shaft 165 feet deep, evidently in an old stream channel. The work was most difficult, owing to the great thickness of the quicksand and gravel encountered; but at the bottom a layer of pay dirt about six feet thick was found, evidently of considerable richness, and giving promise of large returns. No attempts have been made lately at any of these places to test the quartz by assay, but that some of the veins are auriferous was clearly proved by researches of Messrs. Hunt and Michel, twenty years ago. (Report of Progress Geological Survey, 1863-66.) That much of the gold found in the washings is local is evidenced from the finding of ragged nuggets, both as to quartz and gold, the pieces being often found in close proximity to the quartz reefs from which they were evidently derived.

The existence of these old river channels is conclusively established in the valley of the Chaudière, by the work of the St. Onge Company, at St. George, as well as on the Gilbert some years ago. Such channels doubtless occur not only along the side streams, but also along the Chaudière itself, many of which, from the very large size of the nuggets already found, must be exceedingly rich in gold near the bed-rock. The operations of the St. Onge Company, will, therefore, be watched with a great deal of interest.

From the observation of the past season it is evident that the country rock of Ditton, while its auriferous quartz veins, is continuous directly across the country into Roxborough and Marlow. Many of the quartz veins are small, but then generally numerous, and the gold will probably be found to occur in quantity in the small rather than in the large veins.

As in Ditton and on the Chaudière, the quartz veins of Marlow contain gold, as samples can be picked up in nearly every brook, while the assays of the silver ores from the "Marlow silver mines," show in several cases a considerable amount of gold. It is, however, probable that this gold is not distributed uniformly through the quartz-veins, but may exist in the form of pockets. Assays of hand specimens, therefore, do not give a fair idea of the value of the respective veins. What is evidently greatly needed now in the Chaudière district is a good stamp-mill, by which trial crushings of quartz may be made from different localities,

and in this way only can a just idea of the richness of the leads be obtained. The silver-bearing veins of Marlow and Roxborough, though not yet sufficiently developed to pronounce definitely on their value, are evidently of considerable importance. Some half a dozen veins occur, ranging from a few inches to eighteen in thickness. Shafts have been put down in some places to a depth of thirty feet, the vein continuing constant and the quantity and quality of the ore apparently increasing. Assays of samples from different veins show from 29 to 43 ounces silver per ton of 2,000 lbs., and some from the outcrop of the "Senator" vein, a cross vein about one mile south of the main shaft, gave the same assayer 260 ounces. Assays of samples from the main vein by Richards, of the School of Technology, Boston, gave a little over 29 ounces per ton. The property is situated about seven miles south of the Kennebec road near the Maine boundary, and near the proposed extensions of the Quebec Central to join the International railway.

Deposits of iron ore, apparently of large extent, were examined in the vicinity of Sherbrooke—the largest at Belvedère, owned by Mr. E. Clarke, of that city, occupying the summit of a hill about 1,000 feet above the St. Francis at Lennoxville. The country rock is quartzo-chloritic and felspathic schist. Assays of the ore, which is a magnetite, have been made by Mr. Hoffman. It contains 28·39 per cent. of metallic iron.

A second deposit, also a magnetite, owned by Mr. Stephen Smith and others, of Sherbrooke, occurs, with hard jaspy rock and schist, three-fourths of a mile from the Grand Trunk railway. The vein is apparently of large size, and the ore of good quality. About 500 tons of ore have been taken from the outcrop, but though the lack of cheap fuel has prevented its profitable smelting on the spot, the quality and value of the ore and its accessibility are such that a good market should be obtained for a large quantity at paying figures in the neighboring states.

The copper deposits of Capelton are at present quite extensively worked, two companies operating in that locality. The ores are shipped to New York for the manufacture of sulphuric acid, the residue being afterwards worked for copper.

Mr. Adams spent about three months during the past summer in making a careful geological examination of portions of the counties of Terrebonne, Montcalm and Two Mountains, in order to gather the necessary data for perfecting the $\frac{1}{4}$-inch scale geological map of this portion of the province now being prepared for publication.

Four new areas of anorthosite—a formation hitherto erroneously designated Upper Laurentian—were found within this district. Their

boundaries were ascertained, and their stratigraphical relations determined. Several hitherto unknown deposits of crystalline limestone were also discovered; one of them, occurring at Lac Quarreau, being of special value. The settlers in the vicinity were not aware of its existence, and had hitherto been obliged to draw lime from St. Jerôme, a distance of about forty miles. They were informed of its position and true character, and will now build a kiln and burn their lime on the spot. Several deposits of iron ore were also visited, and specimens taken for examination in the laboratory. One of these from near St. Jerôme is now being analyzed, and will probably prove to be an ore of excellent quality.

A number of specimens of building and ornamental stones were also collected for the Colonial and Indian Exhibition.

The Rev. Professor Laflamme, of Laval University, kindly undertook to examine certain doubtful points along the north shore of the St. Lawrence, below Quebec, work needed to perfect the geological mapping of this part of the area embraced in the north-east sheet of the ¼-inch scale map of this portion of the province of Quebec.

Respecting this work, Monsieur Laflamme reports as follows:—

"The formations which were met with are, in the first place, the Laurentian with a well-marked area of labradorite in rear of Château Richer. The labradorite only faintly resembles that which occurs on the upper Saguenay. It is of much lighter color, and above all occurs in bands of greater or less width associated with others of well characterized orthoclase gneiss. Further, it contains small fragments of titaniferous iron ore, like those which occur in the labradorite of the Saguenay, but in much smaller quantity.

"The band of crystalline limestone mentioned in the "Geology of Canada" (1863, p. 46), at Cap Tourmente, extends as far back as the parish of St. Tité. It is a marble, generally full of crystals of green pyroxene, which gives it an appearance like the limestone of Grenville.

"The Cambro-Silurian formations. which occupy all the country between the Laurentian hills and river, are extremely interesting. And they are not wanting in importance from a practical point of view, inasmuch as they furnish the stone, so extensively quarried for lime and for building purposes, at Château Richer, Ange Gardien and Beauport. The Hudson River division also contains beds of freestone along the Little River, which have already been quarried on a considerable scale.

"In relation to the structure, the most interesting fact is the remarkable series of faults which succeed each other from Montmorency to Cape Tourmente. They are probably only the secondary phenomena, caused by the great fracture which has, on the Island of Orleans and elsewhere, carried the Utica formation over the Quebec or Lévis for-

mation, and which is such an important feature of the stratigraphical geology of the province of Quebec.

"Along each of these faults the formations of the Trenton group abut against the Laurentian at a high angle, while, owing to the throw of the faults being irregular, the Trenton limestone often appears between the Utica and the Laurentian. There are three of these faults, shown by Sir W. Logan, north of the St. Lawrence, between Montmorency and Cape Tourmente.

"This region is truly remarkable from the regularity of its post-tertiary terraces. They succeed each other in long undulations, at various elevations down to those which are still submerged at high tide in the salt marshes which border, for a considerable distance, the left bank of the river St. Anne. In many places, excellent bricks are made from the clays of these terraces."

As already stated. Messrs. Low and J. M. Macoun arrived at Lake Mistassini on the 28th of April, but, owing to the breaking up of the ice, were unable to commence work till the 28th of May, when the men were sent back to Lake Apouapmouchouan to bring up the provisions which had been sent there from Lake St. John during the winter. This occupied the men till the 26th June, and, in the meantime, Messrs. Low and Macoun were engaged collecting specimens of natural history and making meterorological observations.

On the 3rd of July, all necessary arrangements were completed, and the party started to continue the survey from the point to which it had been carried by Mr. McOuat in 1871. This work was completed on the 22nd July, the total distance being 139 miles, showing that the length of the lake is less than 100 miles, and it has an average breadth of about twelve miles. The only soundings made gave a depth of 374 and 279 feet; these were between the Hudson Bay post and the mouth of the Rupert. The party being now short of provisions, the men were paid off and returned to Lake St. John, while Messrs. Low and Macoun awaited the arrival from Rupert's House of the Hudson Bay Company's canoes, by which they had made arrangements to descend the Rupert River to James' Bay. The canoes did not arrive till the 20th August, and on the 22nd they left Mistassini, and arrived at Rupert House on the 3rd of September. A track survey was made of the route, the distance being over 300 miles.

From Rupert House they crossed to Moose Factory and thence returned *via* the Moose River and the Canadian Pacific Railway to Ottawa, where they arrived on the 3rd of October.

HUDSON BAY AND STRAITS.

Dr. R. Bell again accompanied, in the same capacity as in 1884, the Hudson's Bay expedition, in the steamship "Alert," under the command of Lieut. Gordon, R. N. In the early part of January he was for some time in Toronto in connection with the work of the Hudson Bay expedition of 1884, and advantage was taken of the open weather to make some geological examinations in the townships of Toronto and Trafalgar, the object being to trace the boundaries of certain formations with a view to complete the geological mapping of the counties of Peel and Halton, at which Dr. Bell spent some time in the years 1859 to 1861, and the maps of which in sheets on a scale of $\frac{1}{4}$ of an inch to a mile are now being prepared for publication. The result of the previous work was given in Sir W. E. Logan's map of Canada (1866), on a scale of twenty-five miles to one inch and described in the "Geology of Canada" (1863.)

Respecting the Hudson Bay expedition, Dr. Bell reports as follows:—

" The steamship "Alert." was sent out for the purpose of relieving the parties in charge of the stations established in 1884 in Hudson's Strait and replacing them by fresh men, also to make geographical exploration and surveys in Hudson's Bay, as well as to collect as much more information as possible in regard to the same class of subjects as in the previous year.

" In order the better to accomplish these objects, it was deemed advisable to start earlier than in the previous year. I was assigned the same duties as on the previous expedition by the steamship "Neptune." But instead of returning home by the "Alert," I was instructed, if circumstances permitted, to come back overland, leaving Hudson's Bay 'at some point between York Factory and Cape Henrietta Maria.' For this purpose I was instructed to take with me an assistant, Mr. James MacNaughton, M.A., and five or six voyageurs with two canoes. It was found, however, that there was no room in the ship for these men and I was therefore obliged to trust to being able to pick up suitable ones after getting to Hudson's Bay.

" Leaving Halifax on the 27th of May, we passed through the Gulf of St. Lawrence and the Straits of Belle Isle, several days being spent at Blanc Sablon. In passing up the Labrador coast, a belt of field-ice appeared to lie between us and the land nearly all along. An unsuccessful attempt was made to enter Nachvak Inlet, but we subsequently learned from the observer there that at that time there was open water between his station and the ice-belt which intercepted us. The "Alert" steamed slowly, and it was the 16th of June before we entered Hudson's

Strait, keeping the north side. From that date till the 6th of July, we remained embayed in the ice, with open water around us occasionally, and drifted up and down off the southern part of Resolution Island. On this day we started for St. John's, Nfld., in order to replenish our stock of coal and to have a new iron plate fixed upon the stem of the ship, the better to withstand the heavy ice we expected to encounter off Nottingham Island, but which we did not meet with. We arrived at St. John's on the 16th and remained there for the above purpose till the 27th, when we again started for the Straits. While the ship was in dock, I utilized the time in making excursions into the country around St. John's and as far as Brigus, to study the geology for comparison with that of certain parts of the Dominion.

"On the 1st of August we arrived at the observatory-station in Nachvak Inlet, and finding all well, we left the next morning, taking with us Mr. Skynner, who had passed the winter there. On the 4th we visited Port Burwell station, to the south-west of Cape Chudleigh, where the party in charge were also all well, and we sailed again early the following morning. On the 22nd we called at Stupart's Bay, Cape Prince of Wales, but found that the party had left for Fort Chimo in their own boat the previous day. Port DeBoucherville, on Nottingham Island, was visited on the 24th, and here we learned that one of the station-men, Inglis, had died of survey, on the 3rd of June. The other two members of the party were relieved and three fresh men left to take their place. Port Laperrière, on the west end of the outer Digges Island, was reached early on the 25th. On the 26th I made a track-survey, by the aid of a steam-launch, around this island, which proved to be eight miles long, and on the 28th we sailed for Churchill, where a meterorological station had been established last year, and arrived there on the 1st of September. Here we experienced great gales of wind, and it was deemed prudent to remain in harbor until they abated, which was on the 7th, and we then steamed out, towing the Hudson's Bay Company's brig "Cam Owen," as she would otherwise have been unable to get to sea and proceed on her way to York Factory. We afterwards learned that, owing to the stormy weather, she did not reach that place for fourteen days, although the distance is less than 200 miles.

"After a careful consideration of the matter, the Severn River was selected as the best route by which to start inland for our canoe voyage southward to some point on the Canadian Pacific railway. The lateness of the season, however, rendered it inexpedient for Lieut. Gordon to go so far out of his way in order to land me at the mouth of this river, and the stormy weather added to the difficulty, as the coast is very low, with shallow water extending far out everywhere in this

neighborhood. Even if it had been possible to land me there by the middle of September, it is questionable if there would have been time to cross this unexplored country, a distance of 500 miles, before the close of canoe navigation, as the waters about the height of land are known to freeze up by the 1st of October. In any case I had no men for the journey, and none could have been obtained at the Severn River at that season of the year. From Churchill we recrossed Hudson's Bay to a large group of islands, off the east coast, between Cape Dufferin and Mosquito Bay. These islands, hitherto almost unknown, run in a northeasterly direction for about 100 miles; they lie mostly between latitude 59° and 60°, and are marked "Sleepers" on some maps, although the next groups to the south of them are called the North Sleepers and the South Sleepers. We made a rough survey of part of the group, at the same time giving names to a number of the larger islands composing it; and Lieut. Gordon and myself suggested that, in order to avoid confusion, this group be hereafter called the Ottawa Islands. They are all of a bare mountainous character, and rise to heights of between one and two thousand feet above the sea.

"I landed upon one of the outermost of the group and found it to consist entirely of a green trappean rock, apparently diorite. The rocks of most of the islands in the northern part of the group had exactly the same appearance, and they are, no doubt, of the same nature; but the most westerly of the larger islands, to which we approached close enough to see it plainly, consisted of stratified masses in distinct layers of great thickness and of different colors and external appearances, all dipping westward or towards the centre of the bay.

"The trap of the island on which I landed was cut by small veins of quartz, containing copper pyrites and it also held thin short seams of asbestos. A small mass of gypsum was detected in a loose fragment. The rocks of this island were distinctly worn by glaciation near the sea-level and the grooves had a northward course, thus confirming my supposition of last year that part of the ice, which probably filled the basin of Hudson's Bay in glacial times, escaped northward into the great valley now occupied by Hudson's Straits.

"We arrived at Digges again on the 12th of September, and while the "Alert" lay in Port Laperrière, I had an opportunity of examining the East-main coast to a point about twenty miles south of Cape Wolstenholme. Gneiss, which in places is mixed with a fine-grained red granite, was the only rock seen.

"On returning through the straits we revisited all the stations at which we had touched on the inward voyage and also called at Ashe's Inlet, North Bluff, which we had been obliged to pass by when coming west. Mr. Ashe, the officer in charge here, had obtained specimens of

mica and graphite from the Eskimo of the mainland on the north side of "North Bay," of the charts. He had himself ascertained the existence *in situ* of a great mass of a very coarsely crystalline greenish-grey hornblende rock on the south side and near the western end of Big Island, on which North Bluff is situated.

"The station at Nachvak was abandoned, and the two men who had remained there for the rest of the summer were brought away. We reached St. John's, Newfoundland, on the 14th of October, and sailed next morning for Halifax, where we arrived on the 18th, and I reached Ottawa on the 26th, having paid off my assistant in Montreal.

"I am indebted to the officers of most of the stations for having collected plants in their neighborhoods. Among the numerous specimens so obtained, Professor Macoun finds a few species to add to those collected by myself in 1884, of which 290 are enumerated in his list published as an appendix to my report of last year. A few bird skins were obtained from some of the station officers and men, the greater number being from Mr. Arthur Laperrière, who should also be mentioned as the principal collector of plants. A number of bird skins and a considerable collection of plants were also obtained by myself, and some valuable notes were made on the natural history of a few of the mammals of the regions visited, partly from my own observations and partly from information supplied by the stationmen and the natives."

New Brunswick.

Professor Bailey continued the work of exploration in New Brunswick, assisted by Messrs. McInnes and J. W. Bailey.

"The principal object of these explorations was to secure the data necessary for the completion of the report and map of the area examined the previous season, and which is now in course of publication; together with the extension of the work to the area immediately to the north, which is embraced in the next section of the geological map of the province in course of construction. With these objects in view, the necessary topographical measurements over both areas were made, including several large and difficultly accessible tracts not previously surveyed, and a study was at the same time made of their geological features. These, within the strict limits of the maps referred to, were found to be very uniform, almost the entire area examined being occupied by Silurian rocks, presenting but little diversity; but it being thought desirable to obtain whatever evidence might be afforded by adjacent regions, bearing upon the succession of the Silurian system and its relations to the Cambro-Silurian, our examinations were extended to embrace portions of such areas both in the State of Maine

and in the Province of Quebec. In the former, a short trip was made through the remarkable chain of the Fish River lakes, adjacent to and connected with the river St. John. The formations about Square or Sedgwick Lake, which have been supposed to include both Silurian and Devonian rocks, were examined, and a large collection of interesting fossils was obtained from them. On the other side of the St. John, the base of the formation was sought, both on the St. Francis and Little Black Rivers, as far as the Quebec boundary, but without success. It was, however, ultimately found upon Lake Temiscouata, and the facts there obtained were thus brought into comparison with those of northern Maine, described by Packard and Hitchcock, and those previously studied by ourselves on the Beccaguemic river in Carleton county. Very remarkable resemblances between these three widely separated localities were observed, suggesting some most important conclusions, but as these are at variance both with the observations of the geologists referred to and with those detailed in the report of 1863 of Sir W. E. Logan, I hesitate to advance them without a fuller and more minute examination of the facts upon which they are based, but shall content myself with stating that some of the observations and statements made by the authors referred to, and tested by us over wider areas, are certainly wrong, while it is now believed that the general conclusion drawn from them are also untenable. In view of these facts, and the further modifications of the views held as to the so-called Gaspé limestones and their relations to the Quebec group suggested by the explorations of Mr. Ells, the desirability of a more detailed and elaborate examination of the Temiscouata region, and of the country, thence to the St. Lawrence, is respectfully suggested for the coming season."

Mr. Chalmers was requested to work out the surface geology of the district comprised within the two quarter-sheet maps, 3 N. E. and 3 N. W. He left Ottawa on the 3rd June for the field of labor, and reports as follows:—

"With the view of obtaining all available information regarding the extent of the quaternary subsidence in the region to be examined, a short time was first spent in the St. Lawrence valley. Between Rivière du Loup and Métis it was discovered on the evidence of fossils, terraces and old shore-lines, that the sea in post-Tertiary times had invaded that valley to a height of, at least, 345 feet above its present level. While pursuing this investigation, another fact of importance was brought to light, viz., that the ice of the glacial period had moved from the Notre Dame Mountains, or the adjacent watershed northward into the St. Lawrence basin, striæ and *roches moutonnées* with the stoss-side to the south having been observed at Trois Pistoles, St. Simon, Rimouski and St. Flavie. These striæ were seen on rocks at different

levels from 100 to 800 feet above the sea. Other striæ, however, having a N. E. and S. W. bearing, were observed below the 345 feet contour line. Great numbers of boulders of Laurentian rocks, which must have been transported thither from the north side of the St. Lawrence, are strewn over the lower grounds. Above the 345 feet contour, the boulders seemed to be largely derived from local rocks and were less rounded. Terraces were also absent, except along river valleys.

"In the Baie des Chaleurs basin a most careful examination failed to detect marine beds at a greater height than 175 to 200 feet above tide level, except, perhaps, at Port Daniel, Quebec, where terraces near the shore were observed at heights of 225 to 240 feet.

"The evidence respecting the quaternary subsidence of the region examined, therefore, as far as it goes, is in agreement with the views already advanced by some geologists, viz., that it is greater towards the north or north-east than in the area south-east of the Appalachians; but the oscillatory movement does not appear to have been uniform, its upper limit not presenting the form of a regular curve either in a north and south direction or transversely to that of the mountain chains. On the contrary, each of the great Palæozoic basins would seem to have been unequally affected by it.

"Glacial striæ were found in the Upper Restigouche valley and on the north side of the Baie des Chaleurs, *i.e.* at Nouvelle, New Richmond, Port Daniel and Point Maquereau, which show that the ice producing them moved from the water-shed in the Notre Dame Mountains towards the Baie des Chaleurs basin. Correlating these with striæ observed on the southern shore of this bay, they indicate that a local glacier of considerable size occupied the western portion of its basin and the estuaries and valleys connected therewith during the ice age, which had its source in the elevated region referred to and moved nearly in a due easterly course. The facts thus far obtained on both sides of the Notre Dame Range, however, point to the conclusion that the existing water-shed near these mountains also shed the ice of the glacial period northward and southward, nearly as the waters due to precipitation are now shed; and further, that the principal part of the Baie des Chaleurs and the estuary of the St. Lawrence were open during the same period, glaciers debouching into them.

"In reference to the season's operations, it may be stated further, that the Restigouche and its affluents, the Quatawamkedgewick, Patapedia, Upsalquitch, &c., were ascended and a series of borometric and other observations taken and the general elevation of the drainage basin of the river ascertained. The forest growth, character of the soil, the extent and fertility of the river-flats or intervales, &c., were also

investigated. All accessible parts of the district, indeed, included in the sheets, were examined, the surface, contour, elevation, extent of arable land, of salt and other marshes, peat bogs, clay and gravel beds, deposits of boulder-clay, kames, &c., were noted so as to be available for mapping them. Attention was also given to the relative values of the soils derived from the different geological formations and kindred matters.

"Bricks and brick clays were collected at Bathurst, Chatham, Moncton, Sussex, St. John and Fredericton for the museum and exhibition.

"Photographs of a dozen or more of the principal forest trees of New Brunswick were taken, and a number of quarries visited to obtain specimens of building stone, &c."

Nova Scotia.

The work done by the Geological Survey during the season of 1885 in Nova Scotia comprises an examination of the country lying to the westward of that described in the summary report of operations for 1883 and 1884. It embraces portions of five counties:—Antigonish, Guysboro', Pictou, Halifax and Colchester. The country along the West River of St. Mary's, west of Sherbrooke gold-field, and north of 15-mile Stream, was entrusted to Mr. Faribault, assisted by Messrs. J. A. Robert and M. H. McLeod. Mr. Fletcher was engaged in the district west of St. George's Bay, the West River and Harbour of Antigonish and along the East River of St. Mary's and East River of Pictou, as far as Pictou Harbour, and was assisted by Mr. John McMillan, and also, later in the season, by Mr. Faribault and his assistants above named. In the southern part of this district is the belt of Devonian rocks, full of fossil plants, already described as extending from L'Ardoise, in Cape Breton, through Madame Island, and from the Strait of Canso to Lochaber, where it is underlaid by fossiliferous Silurian, and by pre-Cambrian rocks, as described by Dr. Honeyman several years ago. From Lochaber, the Devonian rocks keep south of the East River of St. Mary's and the East River of Pictou, and strike the International railway west of Glengarry, from the high land south of Truro, and are unconformably overlaid by the Carboniferous, limestone and associated rocks of the Stewiacke River. They are divisible into several groups, and are frequently cut by veins of iron ore, some of which are of great promise.

To the northward, lie the Silurian, Cambrian (?) and pre-Cambrian rocks of Arisaig, Antigonish Mountains, and McLellan's Mountain, with large beds and veins of iron ore and manganese, which have been worked to some extent in the East River of Pictou, and to which a rail-

way is now projected to connect the mines with the Intercolonial railway and the Pictou coal-field.

North of and overlying the rocks just named, are the Carboniferous strata of Northumberland Strait, two small spurs or basins of which, run, the first up West River of Antigonish as far as James River railway station, the second up the East River of Pictou as far as Sunnybrae. Both of these basins consist of Lower Carboniferous rocks, and hold fine workable beds of limestone and gypsum, and similar rocks underlie the country from McAra's Brook, near Arisaig, to the vicinity of Avondale railway station. These are overlaid east and south of Merigomish by millstone grit, containing beds of sandstone, fit for building and grindstones. A third series of Upper Carboniferous rocks occupies the coast from Big Island, Merigomish, westward to and beyond Pictou Harbour, having the New Glasgow conglomerate at its base and yielding the celebrated grindstones and building stone of Quarry Island, Big Island, Roy's Island, Little Harbour, Pictou and other localities, together with a small seam of coal and beds of an inferior kind of limestone. These Carboniferous rocks, as well as the coal-measures, are fully described in Logan and Hartley's report on the Pictou coal-field. (Report of Progress, Geological Survey, 1866-69.)

Much yet remains to be done, however, among the strata of the mountain range between Cape St. George and McLellan's Mountain before the geology of this interesting and intricate district can be clearly described. Two series at least of volcanic intrusions render the relations of the sedimentary rocks obscure, but it is not too much to assert that the comparatively small thickness of fossiliferous Silurian rocks present on the coast at Arisaig represents but a small part of the volume of the formations anterior to the Carboniferous in the counties of Pictou and Antigonish.

Mr. Faribault gives the following account of his portion of the work:—

"The West River St. Mary runs through an isolated basin supposed by Sir William Dawson to be millstone grit, bounded to the north by the Devonian and to the south by the gold-bearing rocks (Cambrian) of the Atlantic coast.

"Two prominent bands or dykes of granite were observed, associated with the gold-bearing rocks. Like the quartz leads, they follow the strike—east and west magnetic—of the strata. The northern one is one eighth of a mile wide and four miles long. On the north it is bounded by the overlying millstone grit which, near the contact, is largely composed of granitic detritus. One mile to the south is the other dyke mentioned. It has been traced twenty-four miles, and is from one-quarter to one-eighth of a mile wide. To the east it passes

under the millstone grit, and to the west ends in the gold-bearing rocks.

"The silver mine which was worked some years ago at Smithfield, and reported to have yielded rich ore, is in a narrow belt of the gold-bearing rocks, between the southern dyke and the overlying conglomerate of the millstone grit.

"Excellent sandstone for building purposes is found in the millstone grit. Two quarries were seen; one, three-quarters of a mile up McDonald's Brook, and the other on the main West River St. Mary's, a mile and a half below Upper Caledonia."

Six hundred and twenty-one miles of streams and 512 miles of roads were measured by Mr. Fairbault's party, in Antigonish and Pictou counties.

Field work commenced on the 4th June, and was continued into December.

Chemical, Mineralogical and Lithological Section.

Mr. G. C. Hoffmann furnishes the subjoined report of work in this section:—

In the chemical laboratory, attention has been mainly directed to the examination and analysis of such minerals as were deemed likely to prove of economic importance. The work included:—

I.—Analyses of numerous specimens of lignites, lignitic coals, coals and semi-anthracites from the North-west Territory. The greater number of these were found to be fuels of excellent quality. This work constitutes an appendix to the report on "The Coals and Lignites of the North-west Territory."

II.—Analyses of several mineral waters.

III.—Analyses of iron, copper, and manganese ores.

IV.—Gold and silver assays. Of the specimens examined, a great many were from the Rocky Mountains, from localities recently opened up by the line of the Canadian Pacific railway.

V.—Miscellaneous examinations.

"During the period in question, 339 mineral specimens were received—brought or sent—for identification or for information in regard to their possible economic value. In addition to the time devoted to visitors seeking information in this connection, the imparting of such information, in a great many instances, necessitated correspondence by letter. The total number of letters written amounted to 170, by far the greater number of which partook of the nature of reports.

Mr. F. D. Adams has, for the space of nine months, acted in the capacity of assistant chemist. The remaining three months were de-

voted by him to geological examination of the counties of Montcalm and Terrebonne in the province of Quebec.

"The additions to the specimens in the mineralogical section of the museum amounted to 203, including donations from the following individuals:—

F. C. Crean; J. R. Costigan, of Calgary; R. H. G. Chapman, Belleville, Ont.; John Connors; J. K. Davies, township of Eardley, Que.; L. C. Garnett, of Fort McLeod, N.W.T.; J. Moore, Ottawa, Ont.; Alexander Mackenzie, C. E., of Montreal, Que.; J. McArthur, of Hull, Que.; T. McKellar, Port Arthur; W. Ogilvie, D.L.S., N.W.T.; Hiram Robinson, of Ottawa; T. Sheridan, manager Boston Asbestos Packing Company's mines, Thetford, Que.; Richard Trethwey, Ottawa; Ottawa Granite Company, Ottawa; D. B. Woodworth, M. P.

"Mr. P. L. Broadbent has displayed most commendable assiduity and zeal in the labelling of the specimens in this section of the museum, and, as a consequence, considerable progress has been made in this direction, and much has been done tending towards a more perfect arrangement of the whole collection.

"In the early part of the year, Mr. C. W. Willimott, was engaged in the receiving, cataloguing, packing and shipment of mineral specimens for the Antwerp Exhibition, in which work he was assisted by Mr. H. P. Brumel. At a subsequent date he was engaged in making a collection of Canadian economic minerals which was—at the request Mr. H. Wade, the Secretary—loaned to the Dominion Exhibition, held in London, Ontario. In the course of the summer, he visited, in company with Mr. E. A. Evans, C. E., various mines and quarries in the counties of Hastings, Frontenac, Addington and Lanark, in the province of Ontario, and the township of Thetford, and Dudswell in the province of Quebec. The result was the procuring of a great many desirable mineral specimens, and much useful information. More recently he has been actively engaged in the work of receiving, cataloguing and sending off a collection of specimens, intended to represent the mineral wealth of the Dominion at the forthcoming Colonial and Indian Exhibition. In furtherance of this object he has opened up correspondence with the owners of mines and quarries, for the purpose of obtaining specimens of ore, building stones, &c., and such information as they might feel disposed to communicate in the way of mining statistics. Mr. Willimott has throughout been actively assisted by Mr. E. A. Evans."

Biological Section.

In this section, Mr. Whiteaves reports that the first part of the first volume of "Contributions to Canadian Palæontology" was published in August. It contains a descriptive "Report on the Invertebrata of the Laramie and Cretaceous rocks of the Bow and Belly Rivers and adjacent localities in the North-west Territory," and consists of eighty-nine pages of letterpress, illustrated by eleven large octavo lithographic plates. As stated in the text, it is "intended primarily as a palæontological supplement or appendix to Dr. G. M. Dawson's report on the region in the vicinity of the Bow and Belly Rivers, published in 1885, in the Report of Progress of the Geological Survey for 1882-83-84." It is mainly based upon collections made by Dr. Dawson and Messrs. R. G. McConnell, J. B. Tyrrell and T. C. Weston, in the years 1881-84, but in order to make it as complete a presentation as possible of the present state of our knowledge of the invertebrate faunæ of the Laramie and Cretaceous rocks of the Canadian North-west, it contains also a revision of the species from these formations obtained by Dr. Dawson in 1874, in the capacity of geologist to H.M. North American Boundary Commission, and identifications of a few Cretaceous fossils collected by Professor Macoun in 1879."

An article entitled "Notes on the Possible Age of some of the Mesozoic Rocks of the Queen Charlotte Islands and British Columbia" has been contributed by Mr. Whiteaves to the June number of the *American Journal of Science and Art*. Some progress has been made with the manuscripts of the second part of the third volume of "Canadian Palæozoic Fossils," and a commencement has been made of a paper on the land and fresh-water mollusca of the Dominion, based mainly upon collections made by members of the staff of the Survey since 1863.

Acting under my instructions, a systematic catalogue of the zoological specimens on exhibition in Ottawa by the Department of Fisheries has been prepared by Mr. Whiteaves, prior to their being sent to the Colonial and Indian Exhibition. As many of the species had not been accurately determined before, and as some of the labels (especially those of the marine invertebrata) had obviously got misplaced, it was found necessary to make as critical a re-examination of the whole as was possible, of specimens, many of which were stuffed and mounted in closed cases, or which required a microscopical examination for which there was no time. The collection appears to consist of five species of *Pinnipedia* (walruses and seals), two of *Cetacea* (porpoises and whales), ninety-one of fishes, twenty-four of *Crustacea*, one hundred and four of *Mollusca*, three of *Brachiopoda*, three of *Tunicata*, four of

Polyzoa, fifteen of *Echinodermata*, three of *Alcyonaria*, and four of sponges, besides a few specimens of mammals and birds, some of which will be incorporated in another part of the government natural history contribution to the same exhibition.

Twenty-seven mounted specimens of Canadian mammals, and fifty-three of Canadian birds have been added to the museum during the year, all of which have been identified and labelled. Considerable progress has also been made in the re-classification and re-labelling of the fossils in the museum, and many additions have been made to this part of the collection; but further details of the work done in this direction will be found in Mr. Ami's report, by whom (and by Mr. Weston) the larger part of it was done. About two hundred and fifty species of Canadian marine mollusca have been placed upon exhibition in the museum and labelled, of which upwards of one hundred species are from the Atlantic, and nearly one hundred and fifty from the Pacific coast of the Dominion. Efforts have been made, not without success, to make this part of the collection as complete as possible. Two new table cases for recent shells have been constructed early in the year, and these have since been filled, the one with one hundred and eighty-five named specimens of North American *Unionidæ*, and the other with about four hundred and seventy specimens of United States and exotic fresh-water shells, most of which have been re-labelled.

A preliminary examination has been made of the Neocomian fossils from Forward Inlet, V.I., and of the extensive series of recent marine invertebrata from the Strait of Georgia, Queen Charlotte Sound and Quatsino, collected by Dr. G. M. Dawson in the summer.

During the absence of the Director, on field work, for about three months, the duties of Acting Director were performed by Mr. Whiteaves.

The following collections have been received during the year from members of the staff:

G. M. Dawson:—

- One hundred and fifty specimens of fossils from the Neocomian rocks of Winter Harbor, Forward Inlet, Vancouver Island.
- A large series of fossil plants from the Cretaceous rocks of Port McNeil, V.I., also a similar but smaller collection from Nanaimo, V.I. Small collections from two other localities.
- A large number of marine invertebrata dredged or collected in the Strait of Georgia, Queen Charlotte Sound and Quatsino, V.I.
- Forty-four skins of birds and mammals from British Columbia.
- One Indian canoe and other articles of Indian manufacture from Vancouver Island and its vicinity.

R. G. McConnell:—

One hundred and fifty specimens of Devonian and Carboniferous fossils from various points in the Rocky Mountains, east of the summit and between the Canadian Pacific railway and the North Saskatchewan.

J. B. Tyrrell:—

Four hundred specimens of fossils (mostly of plants and invertebrates) from the Cretaceous and Laramie rocks at twenty-four different localities between the Bow and Saskatchewan Rivers. Also, a collection of insects (recent) from the same district.

R. Bell:—

Twenty specimens of birds and twelve of fishes from Hudson Bay and Straits. Forty-three specimens of lepidoptera from Hudson's Straits and Newfoundland. One harp seal (*Phoca Groenlandica*). One fœtal walrus. One "Wenusk" (*Arctomys pruinosus?*). Three meadow mice. Two skulls and other bones of walrus. One skull of bearded seal (*Erignathus barbatus*). One young harp seal and one shark.

Collected by request of Dr. R. Bell and presented to the museum by the gentlemen mentioned:—

From Mr. Arthur Laperrière, of Ottawa:—

Twenty-one specimens of birds and a collection of insects from Digges Islands, Hudson Bay.

From Mr. F. F. Payne, of Toronto:—

Three specimens of birds, eight of crustacea and thirty of coleoptera, from Labrador and Hudson Straits.

From J. R. Spencer, of Churchill:—

Eleven specimens of fishes from Hudson Bay.

From Dr. P. M. Mathews, of York Factory:—

One specimen of *Sorex belli*, a new species recently described by Dr. Dobson.

J. Macoun:—

Skins of three species of mammals and seven of birds (since mounted) from the Rocky Mountain region, on the line of the Canadian Pacific railway. Four species of mice, one ground squirrel, four species of frogs, and two of snakes, in alcohol, and a few land shells from the same district.

Several specimens of Unionidæ and land shells from Lake Erie and the St. Clair River, Ont.

Eugène Coste :—

Twenty specimens of fossils from the Black River limestone of Victoria and Peterboro' counties, Ont.

F. D. Adams :—

Twenty-five specimens of fossils from the Trenton group at Lake St. John, Que.

A. P. Low :—

Skins of marten, mink and otter, from Lake Mistassini.

This branch of the museum is indebted to the following individuals for additions by presentation :—

Rev. W. Winter Seaborn, London, Ont; Prof. E. D. Cope, Philadelphia; A. McCharles, Toronto; W. Ogilvie, D.L.S.; G. R. White, Ottawa; E. B. White, Ottawa; F. H. Harvey, Walsh, N.W.T.; Peter Hill, Hartford, Ont; Master Jeff. Chapleau; L. J. Coursolles, Ottawa; T. G. Coursolles, Ottawa; W. N. Mackenzie, Derby, Ont; W. Purdon, McDonald's Corners, Dalhousie, Ont; Smithsonian Institute, Washington, U.S.; Francis Bain, North River, P.E.I.; W. Craig, Russell, Ont; W. J. Morris, Perth, Ont; Prof. H. Alleyne Nicholson, Aberdeen, Scotland; Rev. G. W. Taylor, Cedar Hill, Victoria, B.C.; Mrs. G. Barnston, Montreal; James Fletcher, Ottawa; W. W. Rochester, Ottawa; Prof. E. J. Chapman, Toronto; G. F. Mathew, St. John, N.B.; W. F. Ganong, St. Stephen, N. B.; J. Townsend, Durham, Ont; S. Herring, Ottawa; Prof. T. Nelson Dale, Toronto.

Some additions by purchase have also been made, including a large collection of insects from Captain Gamble Geddes. This collection consists of over 7,500 specimens, of which about 2,600 are lepidoptera.

Mr. H. M. Ami has continued the work of revising and re-classifying the collection of fossils on exhibition in the museum, under Mr. Whiteaves' supervision. The systematic classification and labelling of the Laramie and Miocene plants of the Souris, Nicola and Similkameen Rivers, and of Quesnel, B. C., which was commenced last year, has been completed, as has also the arrangement and labelling of the fossil plants of the North Thompson reserve and of the Mackenzie River. The fossils of the Gaspé sandstones have been re-classified and labelled, those of the Lower Carboniferous or "Windsor Series" of Nova Scotia have been arranged, mounted and labelled, as have also three cases of the corals of the Corniferous limestone of Ontario. Labels have also been

prepared and printed for the Laramie and Cretaceous fossils of the Bow and Belly Rivers district, described or identified in Mr. Whiteaves' report.

A number of collections of fossils have received a preliminary examination by Mr. Ami and the species has been determined as far as practicable. Among these collections are the following.

Dr. G. M. Dawson:—
Devonian and Carboniferous fossils from various localities in the Rocky Mountains, collected during the past three years.

Prof. A. P. Coleman, Victoria University, Cobourg, Ont.:—
A series of fossils from limestones (probably Silurian) in the vicinity of the junction of the Kicking Horse and Columbia Rivers.

Prof. L. W. Bailey:—
A number of fossils from Oak Bay, Broad Cove, St. Andrews, Little Pokiok Creek and other localities along the Beccaguimic River, New Brunswick.

F. D. Adams:—
Trenton and Utica fossils from the Saguenay and Lake St. John.

T. C. Weston:—
A series of graptolites from the "Cove Fields," and Citadel Hill, near Quebec.

R. McKenzie:—
Cambro-Silurian fossils from Peterboro', Ontario.

Collections of fossils have been selected, labelled and sent to St. Hyacinthe College, P. Q., to the Trinity College, Toronto, and to Mr. W. C. Van Horne. A set of characteristic Canadian fossils, which was sent to the Smithsonian Institution in 1876 and of which the accompanying list was lost at Washington, has been re-labelled and returned to the Smithsonian. Mr. Ami has also devoted some time to a study of graptolites from various localities and geological horizons in the Province of Quebec. He obtained leave of absence for three months during the year, to enable him to visit Europe, and was absent from the 29th of May to the 7th of September.

Most of Mr. T. C. Weston's time has been occupied in museum work. The ethnological collections, formerly exhibited in the upper flat, have been removed to the middle flat, to make room for the collection of Canadian birds and mammals. The former have been re-arranged. The large recent accumulations of fossil bones, and particularly the remains of mammalia from the Miocene of the North-west, have been

prepared for study, and forwarded to Prof. E. D. Cope, of Philadelphia, who has kindly undertaken their examination. The entire series of Carboniferous plants in the possession of the Survey has been cleaned and prepared for exhibition in the museum, and labels for all the species recognized have been prepared. Numerous additional specimens of interest from other formations have also been developed, labelled, mounted and placed on exhibition. About fifty microscopical sections or other preparations of rocks or clays, collected by various members of the staff, have been made. The whole of the wood-cuts used in the reports of the Survey have been classified and arranged in a cabinet made for that purpose.

In June, Mr. Weston devoted three weeks to an examination of some of the exposures of the Island of Orleans, Point Lévis, and the Citadel Hill at Quebec. Collections of fossils were made at each of these points, and especially at a new locality near the Parliament buildings, which has yielded a small assemblage of peculiar interest. In July, Mr. Weston examined the rocks on the St. Francis River, from Melbourne to Hereford. No fossils were detected in these deposits, but a good series of lithological specimens was secured.

Botanical Work.

Prof. Macoun, in his last report, gave details of the botanical work up to 31st December, 1884. At that date he was at work on the second part—Gamopetalæ—of the "Catalogue of Canadian Plants." This was completed and published last spring. It consists of 202 pages, and gives the range and synonomy of 908 species, besides other useful information. After its publication, he worked on the third part of the same catalogue—Apetalæ—until it was time to take the field in the latter part of May.

About the 1st of June he started for the Rocky Mountains, for the purpose of examining the fauna and flora of that little known region which had been opened up by the Pacific Railway the preceding summer.

Thirteen weeks were spent in the mountains and many interesting and valuable discoveries were made. Collections of plants, as well as of birds, etc., were made.

About 1,200 species of plants were secured, including many new to Canada. The flora of the Columbia valley shows conclusively that it is climatically suitable for agriculture.

Particular attention was paid to the avian fauna of the mountains, and 115 species were shot and determined. All the smaller mammals observed were procured and some land shells were collected.

On his return from the mountains he spent a month in western Ontario, ascertaining the distribution of trees along Lake Erie, and procuring wood specimens for the Colonial and Indian Exhibition.

Since then he has been working at the Rocky Mountain collections and those of Dr. Dawson and Mr. J. Fletcher, F.R.S.C., made in British Columbia last year. Mr. J. M. Macoun also made extensive collections at Lake Mistassini, which have been examined and arranged.

On the return of the expedition sent to Hudson Strait and Bay in 1884, Dr. Robert Bell placed in his hands the collections of plants made during the summer. These were examined and named and the results published in the last report of the Geological Survey. The collection of plants brought from Hudson Bay by Dr. Bell last October has also been examined and reported on.

He has also determined about 1,100 species sent from the Department of Public Instruction, Quebec, by D. N. St. Cyr, F.R.S.C. Numerous small parcels from New Brunswick and Manitoba were also examined and named.

Professor Macoun was assisted by Mr. J. A. Macoun for two months and a-half last spring and three months this winter.

There have been mounted and placed in the herbarium during the past year 3,082 sheets of specimens as follows:—

Canadian	1,983
United States	1,061
European	38
Total	3,082

Two thousand nine hundred and fifty-seven species labelled and named have been distributed to various colleges in Canada, or sent in exchange for other plants, to individuals during the year. Two fine collections were sent to Downton College of Agriculture, Salisbury, England. One to the College of Agriculture, Guelph, Ontario, and another to Laval University, Quebec.

Maps.

Much of the time of Mr. Barlow, chief draftsman, has been occupied in the general superintendence of mapping work in the office and laying down projections, and otherwise assisting various members of the field staff in their work. Mr. Barlow furnishes the following memorandum of maps and topographical work in progress or completed during the past year:—

British Columbia. Mr. Bowman has the revised map of the southern interior part of British Columbia in an advanced stage, and it is hoped that work on it may be completed during the present winter.

British Columbia and North-West Territory. Surveys by Dr. G. M. Dawson and assistants, in part of the Rocky Mountains, included between latitudes 49° and 51°30′; longitudes 114° and 117°, are being collated and drawn by Messrs. A. E. Barlow and L. N. Richard. This work is approaching completion, and it is intended to publish a preliminary map of the region on a scale of 8 miles to 1 inch.

North-west Territory.—Mr. McConnell's map of part of the district of Assiniboia is completed and in the hands of the engraver. In addition to the surveys of the Dominion Lands Branch, a great amount of detail in topography has been added by Mr. McConnell and assistants to this area. Mr. J. B. Tyrrell has a sheet similar in area to the last, between the Bow and Saskatchewan Rivers, well advanced. Scale, 4 miles to 1 inch. This it is proposed to publish on a scale of 8 miles to 1 inch.

Manitoba and Western Ontario.—On the area including Lake of the Woods, and in its vicinity, work is still in progress by Mr. Lawson and assistants. The area covered by the map is 3,456 square miles.

Ontario. — A scheme for the geological mapping of the peninsular portion of Ontario in sheets of uniform size, like those employed in Maritime Provinces, has been laid down, and some progress has been made in the compilation of surveys to form a basis for the geological representation. The progress of this work has been delayed by the inaccuracies and incompleteness of the available maps and township surveys of the region, and the almost complete absence of topographical information. The following memoranda indicate the present state of the several sheets: One sheet, No. 115, drawn and engraved, but found unsatisfactory, and Mr. Cochrane was instructed to check the work and make the necessary additions to it on the ground. The work occupied Mr. Cochrane from the 15th of August to the 21st of October, embracing in all an area of 450 square miles. About 50 miles of roads were paced, and 25 miles instrumentally measured, and tracings of a number of townships procured from the Crown Lands Department, Toronto. One sheet, No. 107, prepared for engraving, but found incomplete and inaccurate. Sheets Nos. 112, 113, 118, 119; projection laid down and a considerable amount of topographical work prepared for compilation by Messrs. Coste and Cochrane. Six sheets, Nos. 101 to 106, laid down, and a portion of material prepared

for compilation by Mr. S. Barlow. For five sheets Nos. 114, 117, 118, 122, 123; twenty-three township plans copied, and other information collected by Mr. S. Barlow.

Quebec.—Maps of counties of Ottawa and Pontiac; scale 4 miles to 1 inch. Twenty-two township plans have been copied, and other information collected toward the completion of this work, the compilation of which may go on during 1886.

Quebec and North-east Territory.—Map of Lake Mistassini and adjacent regions, in progress, by Mr. A. P. Low.

New Brunswick.—One sheet (plan 2 S.W.), by Prof. Bailey and Mr. McInnes.

Nova Scotia.—One sheet (plan 4 N.W.) compiled, traced and ready for engraver, by Mr. Ells and assistant—area 3,456 square miles. In connection with the geological mapping of this province, Mr. Fletcher and assistants have made surveys and revised topography of Guysboro' and Antigonish counties with a portion of Pictou county and small parts of other counties.

Library.

The librarian, Dr. Thorburn, reports that during the year 1885, from 1st January to 31st December, 5,339 copies of the Geological and Natural History Survey publications were distributed. Of these, 3,789 were distributed in Canada; the remainder—1,550—were sent as exchanges to scientific and literary institutions and individuals, in America, Europe, India, Japan and Australia.

During the year, 531 copies of the "Report of Progress," in French, were distributed.

Nine hundred and seventy-two publications, including books, transactions, memoirs, periodicals, pamphlets and maps were received as exchanges. There were added to the library, by purchase, 113 volumes, besides fifty scientific magazines and periodicals, on geological, mineralogical and natural history subjects, which were subscribed for.

During the year ended 31st December, 217 volumes were bound; there are still, however, a large number that require to be bound before they can be made fully available for the members of the staff.

There are now in the library about 6,000 volumes, besides a large miscellaneous collection of pamplets.

VISITORS.

The number of visitors to the Museum during the year ended 31st December, 1885, was 13,443. A falling off, as compared with the previous year, of 503.

STAFF, APPROPRIATION, EXPENDITURE AND CORRESPONDENCE.

The strength of the staff at present employed is 50, viz:—professional, 34, ordinary, 16.

During the year, the following were appointed to the permanent staff:—

Mr. Lawrence B. Lambe, as artist, from 1st March.

Messrs. Eugéne Coste, and E. D. Ingall, as mining geologists, from 1st July.

The amount available for the fiscal year, ended 30th June, was:—

Civil-list salaries, appropriation	$ 32,784 00
General purposes, do.	60,468 97
Total	$ 93,252 97

The expenditure may be summarized under the divisions named as follows:—

Pay-list salaries		$31,967 33
Wages temporary employées	$20,541 60	
Exploration and survey	21,258 53	
Printing and lithographing	10,163 20	
Purchase of specimens	4,928 56	
Purchase of books and instruments	951 33	
Chemicals and laboratory apparatus	261 06	
Stationery	731 37	
Incidental and other expenses, including museum and office fittings	2,824 85	
	$61,660 50	
Less paid in 1884	12,651 13	
		49,009 37
Advances to field explorers and others on account of 1885-86		11,003 59
Unexpended balance, civil list appropriation		816 67
Unexpended balance, contingency appropriation		453 01
Total		$93,252 97

The correspondence of the branch shows 8,131 letters sent, and 5,310 received.

In conclusion, I would again refer to the inadequate accommodation, both for museum and office purposes, which is afforded by the building now occupied at the corner of Sussex and George streets. The natural history collections are increasing year by year, and it has already been found necessary to make accommodation in the passages for important collections—the woods and the medicinal plants, the herbarium, and the fine entomological collection purchased during the year from Captain G. Geddes. The numerical strength of the staff has likewise been increased to such an extent that when, as during the winter, all are at work in the office, the available space for drawing-tables and desks is wholly insufficient, and the interruption incidental to a large number working in one room seriously hinders the progress of the work in hand. I trust that for these reasons some steps may be taken at an early date to obviate the inconvenience now existing. A ready and comparatively inexpensive mode of doing so was suggested in my summary report for 1883, which, if adopted, would, at the same time, greatly improve the external appearance of the museum building.

In a recent report by V. Ball, M.A., F.R.S., Director of the Science and Art Museum, Dublin, on the museums of America and Canada, the following notice of the Ottawa Geological Museum appears.

"Of the smaller museums which I visited in America and Canada, there was not one which I saw with as much pleasure and interest as that which owes its origin* and development to the energy and ability of Dr. Selwyn, Director of the Geological Survey of Canada.

"Although known as the Geological Museum, and although the principal part of the available space is devoted to the illustration of the minerals, rocks and fossils of Canada, still there is room for the display of a small ethnological collection and the nucleus of a series of Canadian mammals and birds. ......

"The method which has been adopted for the display of the specimens is orderly and attractive, and the system of labelling, if not the best, is good, but is especially noteworthy as being unique—at least, so far as my experience goes.

"For the geological formations, glass slips, with the names painted in black, are backed with coloured paper, the tints used being the same as are used to indicate the formations on the official maps. Thus the eye may become trained to read at a glance the meaning of a geological map, without the necessity of having frequent recourse to an index of colors. Other labels are painted in black on slips of ground glass. The advantage of this method would be most apparent in a damp climate—

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* This is a mistake. It owes its origin in Montreal to my predecessor, Sir W. E. Logan. A. R. C. S.

such, say, as Calcutta, where paper labels suffer from the depredations of insects.

"The several series representing stratified rocks of Canada are very complete, and just such as a local museum ought to have. They proved of great interest to many of the English and American geologists who visited Ottawa during the Montreal meeting of the Association.

"Specially noteworthy is a magnificent block, exhibiting the structure of what is known as *Eozon Canadense*. In an adjoining case are specimens of igneous rocks which, as they possess a somewhat similar structure, tend, in the opinion of some authorities, together with other facts, to throw discredit on the opinion maintained by Sir William Dawson and Dr. Carpenter, as to the organic origin of this structure.

"The useful minerals of Canada are well illustrated in this museum by admirable series of specimens, and polished slabs of the ornamental stones are displayed on brackets on the walls, with good effect.

"Though unpretentious and practical, the general effect and appearance of this museum is such as to attract non-scientific as well as scientific visitors, a matter of no slight importance in a country where its very existence may be said to depend on the popular vote. Its continuance and development are matters of great importance to the mineral industries of the Dominion, and if, on this account alone, it is supported liberally by the state, science will not fail to reap a share of the benefit so conferred."

Referring to museums, it may not be out of place to call attention to what is being done elsewhere in this connection. In New South Wales, one of the Australian colonies, with a population of only about 850,000, I find, from a report recently received, that the appropriation for the year 1884, for the maintenance of the museum in Sydney, was £8,750 stg., or about $43,750.

The figures relating to visitors to the Sydney Museum are also somewhat remarkable. They are for 1883, 137,401, being: week days, 86,-114; Sundays, 51,287, apparently showing that there is a very large class of persons whose daily avocations prevent them from taking advantage of the means of instruction, and the ennobling influences which the study of nature's wonders, as displayed in a well arranged museum, cannot fail to afford. In this matter the Australian Colonies must be conceded to have made an advance in the promotion of knowledge and civilization. I would respectfully suggest, for the serious consideration of the government, the desirability of permitting the museum to be open for visitors on Sunday afternoons.

ALFRED R. C. SELWYN,

Director.

ADDITIONS TO THE LIBRARY.

FROM JANUARY 1ST TO DECEMBER 31ST, 1885.

BY PRESENTATION.

CANADA.

Department of Inland Revenue, Ottawa :—
- Reports, Returns and Statistics for 1884.
- Report on Canal Statistics, Supplement No. 1 to Report for 1884.
- Report on Inspection of Weights, Measures and Gas, Supplement No. 2 to Report for 1884.
- Report on Adulteration of Food, Supplement No. 3 to Report for year 1884.
- Return of claims for Drawback on goods for export, 1885.

Department of Finance, Ottawa :—
- Report of the Superintendent of Insurance for year 1884.
- Abstract Statements of Fire and Inland Marine Insurance Co.'s in Canada for 1884.
- Shareholders in the Chartered Banks of the Dominion of Canada, 1884.

Auditor General's Office, Ottawa :—
- Report on Appropriation Accounts for year 1884.
- Public Accounts of Canada for year 1884.
- Estimates of Canada for year 1884.

Department of Justice, Ottawa :—
- Report for year 1884.

Department of the Interior, Ottawa :—
- Annual Report for 1884, two copies.
- Report of the Commissioner of the N. W. Mounted Police Force, 1884.

Department of Public Works, Ottawa :—
- Report of the Chief Engineer of Canals for 1884.

Department Railways and Canals, Ottawa :—
- Annual Report for year 1884.
- Railway Statistics of Canada for year 1883-4.
- Reports on the Proposed Short Line Ry. from Montreal to the Maritime Provinces, 1885.

Department of the Secretary of State, Ottawa :—

Annual Report for year 1884.

Return for all orders in Council relating to Licenses to cut timber on lands of Fort William Reserve, 1885.

Reports relative to manufacturing interests in existence in Canada. 1885.

Report of the Royal Commission on Chinese Immigration, 1885.

Report of the Board of Civil Service Examiners of Canada for 1884.

An Act to amend the Civil Service Acts of 1882, 1883.

Returns of Names, Salaries, &c., of all promotion appointments to C. S. for year 1883-4.

Post Office Department, Ottawa :—

Annual Report for year 1884.

Official Postal Guide, Canada, January, 1885.

Department of Indian Affairs, Ottawa :—

Annual Report for 1884.

The Treaties of Canada with the Indians of Manitoba, the N. W. T. and Kee-wa-tin, by Hon. Alex. Morris, 1880.

Department of Marine and Fisheries, Ottawa :—

Preliminary Report on the Fisheries of Canada for 1884.

Seventeenth Annual Report for year 1883-4.

Tables of the Trade and Navigation of the Dominion of Canada, 1884.

Report of the Hudson's Bay Expedition under command of A. R. Gordon, R. N., 1884.

Report of the Meteorological Service of the Dominion of Canada for 1882, by C. Carpmael, M. A.

Report Department of Fisheries, 1884.

Department Militia and Defence, Ottawa :—

Annual Report for 1884.

Department of Agriculture, Ottawa :—

Report for year 1884.

Report on Canadian Archives for 1884.

A Guide Book containing information for settlers, 1885.

Annex No. 3 to Report for year 1884, Abstracts of Returns of Mortuary Statistics and Evidence.

Dominion von Mineralien und ihre Localitaeten, 1885, by H. B. Small.

Dominion von Waldungen Bauholz und Waldprodukte, 1885, by H. B. Small.

EDOUARD J. LANGEVIN, *Ottawa* :—

Debates of the Senate, Dominion of Canada, Vols. 1, 2, 1885.

J. G. BOURINOT, *Ottawa* :—

List of Members of the House of Commons, 1885.

House of Commons, Ottawa :—

The House of Commons Debates. Vol. 17.

Library of Parliament, Ottawa :—

Supplements to the Alphabetical Catalogue, from Jany. 1880 to Jany. 1885.

Natural History Society, New Brunswick:—
Bulletin No. 4.

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GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA
ALFRED R. C. SELWYN, LL.D., F.R.S., F.G.S., DIRECTOR.

PRELIMINARY REPORT

ON THE

PHYSICAL AND GEOLOGICAL FEATURES

OF THAT PORTION OF

THE ROCKY MOUNTAINS,

BETWEEN LATITUDES 49° AND 51° 30′.

BY

GEORGE M. DAWSON, D.S., F.G.S.,

Associate Royal School of Mines.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.
1886.

TO ALFRED R. C. SELWYN, LL.D., F.R.S.,

Director of the Geological and Natural History Survey of Canada.

SIR,—I beg to submit herewith a report on a portion of the Rocky Mountains extending from the International Boundary northward to the head-waters of the Red Deer River.

I have the honour to be,

Sir,

Your obedient servant,

Ottawa, July, 1886.

GEORGE M. DAWSON.

NOTE.—Where not otherwise stated, the bearings throughout this report are with reference to the true meridian.

With the exception of the heights of stations on the railway line, the elevations given are based on barometric determinations, checked by comparison with barometric records at Calgary, Benton and Spokane Falls.

PRELIMINARY REPORT

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PHYSICAL AND GEOLOGICAL FEATURES

OF THAT PORTION OF

THE ROCKY MOUNTAINS,

BETWEEN LATITUDES 49° AND 51° 30′.

This report is intended as a preliminary geological and general account of that portion of the Rocky Mountain range included between the 49th parallel on the south and the upper waters of the Red Deer River, (about latitude 51° 30′,) to the north. The Rocky Mountain Range proper, in this region, is definitely limited to the south-west by the great Columbia-Kootanie Valley, which separates it from the Selkirk and Purcell ranges, while to the north-east, the edge of the Palæozoic rocks may be regarded as its boundary. The width of the range, thus naturally outlined, is about fifty miles. The length of the portion of the range here treated of in a north-west and south-east bearing is about two hundred miles, while the approximate total area covered by this report and the accompanying map is about ten thousand square miles. **Area embraced**

The summit of the Rocky Mountains here constitutes the line of watershed between the Columbia and its tributaries, and the South Saskatchewan, the former flowing to the Pacific, the latter eventually reaching Hudson Bay. This report includes, on the north-east slope of the range, almost all the sources of the tributaries of the last-mentioned river. These, in order from north to south, may be enumerated as follows:—The Red Deer; the Bow, with its tributaries, the Kananaskis, Elbow, Highwood and Sheep; the North, Middle and South Forks of the Old Man, with Mill Creek, Pincher Creek and the **River systems draining the area.**

Waterton River. The Kootanie and Columbia rivers, flowing in opposite directions along the south-west side of the range, are fed by numerous rapid streams, the courses of most of which are comparatively short. The Kicking Horse River is the only notable affluent of the Columbia in this district. Of the rivers joining the Kootanie on the east, Wild Horse Creek, the Bull, Elk and Tobacco Rivers are the most important. The Flat-head River, which drains the central part of the range near the 49th parallel, flows southward, but eventually also joins the Kootanie.

Order observed in report.

The method followed in the arrangement of the matter in this report is as follows:—

A brief account is first given of previous geographical and geological explorations in the part of the Rocky Mountains to which it relates, with other particulars of an historical character for the district. A general description of the physical features and the bearing on these of some points of the geological structure follows, together with notes on the climatic features and general character of the vegetation. To this succeeds a description, in such detail as is deemed essential, of the various routes followed and surveyed, with which are incorporated the geological observations made on these routes. This portion of the report naturally resolves itself into a descriptive account of a number of passes which afford routes across the mountains and of the geological sections met with on these, together with similar details respecting a number of trails and valleys connecting these passes or lying between them. The routes followed during the exploration were selected either as those most easy of travel, or as those likely to afford important information as to the character of the country. Though considerable intermediate tracts remain as yet unexamined, they are, as a rule, those less likely to be entered by travellers or prospectors, being comparatively difficult to penetrate, owing to the dense character of the forest growth or to other circumstances.

The system adopted, of incorporating the geological observations with the general description of routes, is not one in general to be commended, but is justified in this instance by the purely reconnaisance character of the work reported on, and by the convenience of reference to the main facts of whatever class met with in each part of the district, which are thus together embodied in a given part of the report. These general descriptions are, however, supplemented in a subsequent chapter by a systematic, synoptical description of the geological features, to which are appended details of the useful minerals afforded by the district or known to occur in it.

Geographical Exploration and Data for Map.

Previous to the preparation of the accompanying map, the only original map giving with approximate accuracy the general features of the district has been that published in connection with Captain Palliser's report.* This is based on track-surveys made in part by Captain Palliser himself, in part by Captain Blackiston, but chiefly by Dr. Hector, who acted as geologist to the expedition under Captain Palliser. The representation of this part of the mountains on general maps of British Columbia and the North-west Territory are substantially copies, more or less accurate, of Palliser's map, the changes introduced from time to time being seldom in the direction of greater accuracy. The time spent by Captain Palliser and the members of his expedition in this particular district was, however, necessarily very limited, its examination being a portion only of a much more extended exploration; and the scale of his published map is too small for the representation of any but the more important features in a generalized manner. No portion of the geographical outlines of Palliser's map (with the exception of the western part of the Kananaskis Pass) has, therefore, been incorporated in that accompanying this report, though care has been taken to retain the names then adopted for peaks, rivers and mountain ranges. Previous maps. Palliser's map.

The joint maps of the North American Boundary Commission, 1858–1862† represent a belt of about ten miles near the 49th parallel, (which constitutes the International boundary), in considerable detail, on a scale of $\frac{1}{60000}$. While, however, the main lines shown on these were instrumentally surveyed with sufficient accuracy, much of the topography is represented in a very unsatisfactory manner, and where checked by myself, has been found in many places to be largely hypothetical. The Boundary Commission of 1872–1874, working eastward, defined the 49th parallel up to the point on the main watershed at which the work of that above alluded to stopped. The joint maps subsequently published‡ overlap those of the first commission by about ten miles and represent a belt of country of similar width, the topographical features being given with general accuracy. While, therefore, these maps have been used as a basis for the representation of the part of the district to which they apply, the topography has been improved wherever our examinations rendered this possible. On the north-east, some of the lately run lines of the Boundary Commission maps.

* Index and Maps to Captain Palliser's Reports. London, Government, 1865.

† Detailed maps of the North-West Boundary between United States and British possessions.

‡ Joint maps of the Northern Boundary of the United States. Washington, Government, 1868.

Dominion Land Surveys.

Dominion Land Survey reach the base of the mountains proper, and serve to fix certain points with accuracy. The line of the Canadian Pacific railway, following the Bow and Kicking Horse rivers, is also the result of instrumental survey, to which much has been added by lines run (in 1884) by Mr. T. Fawcett, D.L.S., up the Bow Valley to the head-waters of the river. Connecting with these are some local surveys made for the purpose of defining timber limits on the Kananaskis and Spray rivers.

Information incorporated in present map.

With the exception of the lines above detailed, no instrumental surveys are available for the district, and besides what appears on the Boundary Commission maps, little attempt has been made to indicate the topography on these lines in any systematic manner. In conducting the geological examination of the region, it has, therefore, been necessary throughout, to maintain a system of careful track- or paced-surveys which, in constructing the map, have been tied-in with fixed points on the instrumental lines as far as these are available. The longitudes of intermediate points have been fixed as far as possible by long bearings on prominent summits, and the latitudes of about one hundred places have been determined with a good 7-inch sextant. From the proved general accuracy of these track- and paced-surveys, and their interdependence, it is believed that the outlines represented on the accompanying map will be found correct within small limits of error. The topographical detail is filled in from sketch-plans and profile sketches, and in the vicinity of the lines of travel is substantially accurate. That indicated at some distance from travelled routes is less trustworthy, but where the mountains have not been actually sketched no attempt has been made to delineate them. While the present map must therefore be considered as merely preliminary, its publication is justified by the want of any detailed information respecting the district, which is now attracting the attention of explorers for coal, metalliferous minerals and timber.

Connection with Bow and Belly Rivers map.

In the geological map of the country in the vicinity of the Bow and Belly Rivers, published with the report of 1882–84, the mountains constituting the eastern outline of the Palæozoic rocks are indicated, together with a part of the Cretaceous basin which occurs west of the first limestone range and within the area of the mountains proper. The present map, therefore, to some extent overlaps that one.

Surveys.

The writer first visited the region here reported on in 1874, as geologist to the second of the above-mentioned Boundary Commissions, but his observations were at that time confined to the immediate vicinity of the eastern half of the South Kootanie Pass. In 1881 he re-examined the same portion of this pass, and explored the eastern slope of the Crow Nest Pass, and the upper part of the Bow River nearly to

the position now occupied by Canmore station. In 1883, about twelve weeks were spent in this part of the mountains, and in 1884 the greater part of the working season, or about seventeen weeks, were devoted to the region. In 1883 he was assisted by Mr. J. B. Tyrrell, B.A., and in the ensuing year by Mr. James White, C.E., both these gentlemen being chiefly occupied with geographical and topographical work.

Though this portion of the Rocky Mountains had been traversed by Howse in 1810, who followed, (according to Dr. Hector,) the North Saskatchewan and Blaeberry rivers, by Sir George Simpson in 1841, (as elsewhere more fully noted), by James Sinclair, and by at least two parties of 'emigrants' in 1841 and 1854,* no authentic information for any passes south of the Athabasca Pass was available at the time of the inception of Palliser's expedition in 1857. The Athabasca Pass, north of the region embraced by the present report, had long been employed as a route of trade by the Hudson Bay Company. It was traversed in 1810 by the geographer, David Thompson, and was followed by the botanist, Douglas, in 1827. Knowledge of region in 1857.

So far as I am aware, the first published account of travel in this part of the mountains is that contained in the narrative of Sir George Simpson's journey. He crossed this portion of the range on his way to the Pacific coast in August 1841, but his narrative did not appear till 1847.† His description is very indefinite, so much so, that without actual local knowledge of the region it is impossible to identify his route. Having, however, satisfied myself on this point, it may be of interest to place the result on record, as his journey dates back about to the pre-historic epoch for this region. After travelling south from Edmonton he entered the mountains by the Devil's Gap, north of the Bow River (as surmised by Dr. Hector) and passed along Devil's Lake, which he says he named 'Peechee Lake,'‡ after his half-breed guide, whose usual hunting ground was in its vicinity. Peechee, though a half-breed, was at that time a chief among the Rocky Mountain Crees. Simpson then crossed Cascade River and Forty-mile Creek (mentioning the mountain now called Cascade Mountain) and travelled, I believe, up the Bow Valley to Hole-in-the-wall Mountain, to which his remarks on p. 119 (Vol. I.) refer. He crossed the watershed range by the pass designated by his name on the map, as rendered evident by the time (seven hours) occupied in travelling from the Bow River Crossing to the summit. Had he gone by the Sir George Simpson's narrative. His route.

* See Blackiston's report in Further Papers, etc., p. 66 and Sir G. Simpson's Narrative.

† Narrative of an Overland Journey Round the World. London, 1847.

‡ This name has never, I believe, appeared on any map, or obtained any currency. The lake is now so well known as Devil's Lake that I have not endeavoured to revert to Sir G. Simpson's name, but have attached the name of Peechee to a high mountain to the south of the lake.

White Man's Pass the travelling time would have been much greater, by the Vermilion Pass much less than that specified. The White Man's Pass was, however, probably that taken by the party of 'emigrants' to which he refers as having crossed in the same year (p. 126); the emigrants being guided by an Indian known as Bras Croche.

Simpson then followed down the Kootanie Valley for some miles, and crossed to the Columbia Valley by the Sinclair Pass. He describes the wild gorge on the west end of that pass and refers to the 'Red Rock,' a conspicuous feature there. Near the mouth of this pass he met a half-breed named Berland, sent with horses for him from Ft. Colville. He visited the hot springs near the lower end of the Upper Columbia Lake (p. 128). From the Columbia-Kootanie Valley he struck across south-westward to Colville by the Grand Quête River and lakes—the Choe-coos River of Palliser and Moyie of later maps.

Routes examined by Palliser's expedition in 1858

The routes of Captain Palliser and members of his party in this part of the mountains were as follows,—In August and September, 1858, Captain Palliser traversed the Kananaskis Pass westward, followed the Kootanie Valley southward on the west side of the range, and returned to the east side by the North Kootanie Pass. Captain Palliser notes that he had been informed of the existence and situation of the Kananaskis Pass by a half-breed named James Sinclair, in 1848, when in the western Indian country of the United States.

In the same year, Dr. Hector entered the mountains by the Bow Valley, crossed the watershed by the Vermilion Pass, followed down the Vermilion River and up the Kootanie to its source, down the Beaver-foot, and back over the watershed range by the Kicking Horse Pass, now adopted for the railway. He then followed the Bow River to its source, and the Little Fork and North Saskatchewan rivers out to the eastern foot-hills.

Captain Blackiston, during the same summer, traversed the North Kootanie Pass westward, returning eastward by the South Kootanie or Boundary Pass, and rejoining the expedition at the winter quarters at Fort Edmonton.*

Routes followed in 1859

In the summer of 1859, Dr. Hector again entered the mountains by the Bow Valley, and crossed from it northward by the Pipe-stone Pass to the North Saskatchewan. He then followed the latter up and reached the Columbia by the Howse Pass, and finding it impossible to proceed further west or north-west, travelled southward by the Columbia-Kootanie Valley to beyond the 49th parallel. Captain Palliser,

* Further Papers relative to the Exploration by the Expedition under Captain Palliser, etc. London, Government, 1860.

during the same season, again crossed the mountains by the North Kootanie Pass on his way westward to the Pacific coast.

Within the limits of the region embraced by the present report, a few features, such as the larger rivers, had appeared by name on maps previous to the date of the expedition under Captain Palliser. Other names introduced on the map resulting from that expedition, were those locally in use by half-breeds or Indians, or translations of these, but a considerable number of names were also given by the members of the expedition. It has not always been easy to identify the features to which some of these names were intended to apply, particularly in the case of mountains, which—owing to its small scale—are shown in a very generalized way on Palliser's map, and do not always correspond with the description of their position given in the text. In placing the names on the accompanying map, I have carefully compared Palliser's reports and map in the light of my own knowledge of the localities, with the purpose of doing full justice to the work of the expedition. While doing so I have drawn out the subjoined list of places named by the several members of Palliser's expedition, which may be useful for reference.— Origin of names Identification.

Named by Captain Palliser.—Kananaskis Pass, Palliser River, Mounts Fox, Back and Sabine, and the Stanford, Hughes and Macdonald Ranges. Windigo Mountain and Deception Mountain cannot be identified. The name Dunraven Range was applied to an irregular region of hills and plateaus which cannot be individualized, and is consequently omitted. Names given by Capt. Palliser.

Named by Dr. Hector.—Cascade Mountain, Mount Rundle (after the missionary of the same name), Mount Ball (after the Under Secretary of State for Colonies in 1857), Mount Lefroy (after General Sir H. Lefroy), Brisco Range (after Capt. Brisco, of the 11th Hussars, a fellow traveller); Mounts Hunter, Goodsir, Balfour, Murchison, Forbes, Lyell, Richardson and Molar; Sullivan's Peak, (after a member of the expedition), Castle Mountain (N), on the Bow Valley; Terrace Mountain, Saw-back and Mitchell Ranges, (the latter after a travelling companion of Capt. Brisco,) Kicking Horse River and Pass, Blaeberry River, Howse Pass and Simpson Pass. A few of these localities lie beyond the northern limit of my map. By Dr. Hector.

Named by Captain Blackiston.—Gould's Dome (doubtfully identified, but retained), Livingstone Range, Castle Mountain (S), North and South Bluffs on the Wigwam River, The Steeples, Galton Range. 'The Family' and 'The Pyramid' mountains, seen from the foot-hills south of the Kananaskis River, cannot be identified. By Capt. Blackiston.

Named by Mr. Bourgeau, Botanist to the expedition.—Grotto, Pigeon and Windy Mountains and Lac des Arcs.

Other names on Palliser's map.

Mounts Yarrell and Kirby and Spence, and Waterton Lake, are on Blackiston's route, and appear on his and on Palliser's map. The last-mentioned name was, with little doubt, given by Blackiston, as he refers to it in his report dated Fort Carleton, 1858. The two former, with Newman's Peak and Mount Wilson, were probably also given by Blackiston, though nothing is said of them.

The following names in this district appear, so far as I have been able to ascertain, for the first time on Palliser's map, but are either not mentioned in the reports, or at least no statement is made as to their origin:—Palliser Range, Goat Mountain, Mount Vaux, Fairholme Mountains, Pipe-stone Creek, Beaver-foot River, Fisher's Range, Mount Robinson, Mount Fox, Mount Back, Mount Nelson, Mount Head (doubtfully identified), Crow's Nest Mountain, and Lussier River, Skirmish River (now known as St. Mary River), Bad River (now Bull River), and Wigwam River.

Names on Boundary Commission maps.

The following are names of places which appear on the maps of the first International Boundary Commission.—A-kwote-katl-nam Lake (now Waterton Lake), Kin-nook-kleht-nan-na Creek (now Kootanie Brook), Camp Akamina, Kish-e-nehn Creek, Kintla Lakes, Kish-ne-neh-na Mountains, Boundary Mountains, Kintla Mountains, Yak-in-i-kak Creek, Wigwam River, Ak-o-no-ho Creek, Tobacco River.

Names now added.

In adding the names of places which appear for the first time on the map accompanying this report, I have endeavored, as far as possible, to ascertain and perpetuate those which have come into common use. A number of these date back only to 1881, when the railway surveys in this district were first undertaken, and others have been given since the completion of the line.

Where found necessary for descriptive purposes, I have taken the liberty of naming a number of features not previously designated.

Paucity of Indian names.

Where Indian names exist, these or their equivalents in English are employed, but it is a remarkable circumstance that the Stoney Indians attach definite names to very few of the features in the region, whether mountains or rivers. As these Indians are known to be recent immigrants, and to have occupied the district for about forty years only, the paucity of names might be supposed to be accounted for by this fact. The Stoneys, however, have since incorporated with themselves the families of Mountain Crees who formerly hunted here, and many of the names which can be ascertained are either Cree or their equivalents in Stoney. I am, therefore, led to believe that the Crees themselves had come comparatively recently into possession of the region, from which they expelled some hostile tribe, probably

Cree and Stoney Indians recent immigrants.

of the Kootanie (Kootenuha) stock. This supposition finds confirmation in the statement of the missionary, De Smet, who says that some years previous to the date at which he wrote (1849), the Crees and Assiniboines inhabiting the Athabasca region had been forced to move southward, owing to the scarcity of game, in search of buffalo. It may probably have been at about this time that the Crees pushed their way into this part of the mountains. The present tribe of Rocky Mountain Stoneys (or Assiniboines) is known to be related to the Athabasca Assiniboines. These, according to De Smet, separated from the main body of the same people to occupy the Athabasca region about sixty years before 1849, or in 1790.*

More detailed enquiry among the Kootanie people than I have been able to make, might settle the question as to their former territorial claims. It is certain, however, that tradition relates constant feuds and repeated raids across the mountains between the Kootanie and the Blackfoot tribes, and that the former have been accustomed from time immemorial to cross to the eastern plains to hunt buffalo. It is also probable from the habits of the Blackfoot people, who are essentially plain Indians, that they would not willingly inhabit for any length of time these mountain fastnesses.

Previous Geological Explorations.

Dr. Hector's reports.

The first published geological information for this part of the Rocky Mountains is that contained in Dr. Hector's reports and journals † in connection with Palliser's Expedition. The substance of the geological reports is also given in a systematic form in a paper, accompanied by a map, by Dr. Hector, in the Quarterly Journal of the Geological Society.‡

Mr. Bauerman's report.

In 1861, Mr. H. Bauerman, attached as geologist to the first of the Boundary Commission expeditions above referred to, visited and examined that part of the present district near the 49th parallel. The result of his investigations, however, remained unpublished till 1885, when it appeared in the last report of the Geological Survey (1882-84), Mr. Bauerman having kindly communicated his manuscript report for that purpose.

* Western Missions and Missionaries, Rev. P. J. De Smet, New York, 1859.

† Papers relative to the Exploration by Captain Palliser, etc. London, Government, 1859.

Journals, Detailed Reports and Observations relative to the Exploration by Captain Palliser, etc. London, Government, 1863.

‡ Vol. XVII., p. 388, see also Edinburgh New Phil. Jour., N.S., October, 1861. Having had occasion to re-examine many of Dr. Hector's routes in the North-west Territory and Rocky Mountains, the writer wishes to note the great general accuracy and value of the work done by Dr. Hector, whether geographical or geological.

Other reports and papers.

Under the title of "Physical Geography of the North-west Boundary of the United States," Mr. George Gibbs published, in 1872, in the Journal of the American Geographical Society, a paper giving an account of the orographic features of the region in the vicinity of the 49th parallel, with some notes on its geology. This paper is founded on information gained by Mr. Gibbs while connected with the United States contingent of the same Boundary Commission, to which Mr. Bauerman was attached. Mr. Meek subsequently described a few Carboniferous fossils obtained by Mr. Gibbs at Katlahwoke Creek, in the Rocky Mountains.* He states his belief that this locality is the furthest north in the range at which rocks of this age had been determined by organic remains, but in this belief he was in error, as Dr. Hector had many years previously recognized Carboniferous limestones much further north.†

In The Professional Papers of the Royal Engineers (Paper 14, Vol. III., read January 22nd, 1864,) Lieutenant Wilson, R.E., gives some account of the geography of the same region described by Mr. Gibbs, together with details as to the mode adopted in fixing the boundary line.

In 1874, the writer, as previously stated, made a geological examination of a portion of the South Kootanie Pass and its vicinity, including the valley of Akamina Brook to the boundary monument on the summit ridge. The result of this work forms Chapter III. in the Geology and Resources of the 49th parallel,‡ where a geological section of the portion of the pass examined and several sketch sections of mountains are given. The features of the region are again summarized in a sketch of the geology of British Columbia, published in the Geological Magazine,§ and in the Sketch of the Physical Geography and Geology of the Dominion of Canada.|| Preliminary notices respecting the general structure of the part of the range included in the present report also occur in the reports on the district in the vicinity of the Bow and Belly rivers.¶

Mr. H. H. Winwood, in a letter to the Geological Magazine, in 1885, announces the discovery of Cambrian fossils in the Kicking Horse Pass.**

The publications above noted are, I believe, the only ones bearing on the geology of the region previous to the report herewith presented.

* Bulletin U. S. Geol. & Geog. Survey, Vol. II., p. 351, 1876.

† See his report and paper above cited.

‡ Montreal, 1875.

§ London, April and May, 1881.

|| Published by the Geological Survey, 1884.

¶ Reports of Progress, Geological Survey, 1880-82 and 1882-84.

** N.S. Dec. III., Vol. II., p. 240. See also 'Science,' Vol. III., p. 647.

General Orographic Features.

The portion of the Rocky Mountains embraced by this report may be regarded, for several reasons, as one of particular interest and importance. It is the most northern portion of the range of which any systematic geological—or indeed geographical—exploration of a connected character has yet been made, and it differs very considerably in character from that part of the range which traverses the territory of Montana, where the mountains are comparitively diffuse and irregular in outline. The northern portion of the district is now traversed by the Canadian Pacific railway, which renders it easily accessible, and whether from the point of view of the geologist, botanist or zoologist, or regarded merely as an alpine region affording the most striking and attractive scenery and unlimited opportunities for mountain climbing and exploration, it is likely to attract in the near future many visitors. Apart from the circumstances of the discovery of various metalliferous deposits already made, the existence of extensive basins of newer rocks holding numerous seams of excellent coal gives promise of important developments in the near future. Interest attaching to the region.

The term Rocky Mountains is frequently applied in a loose way to the whole mountain region bordering the west coast of North America, which is more appropriately—in the absence of any other general name—denoted as the Cordillera belt, and includes a number of mountain systems and ranges, which on the 40th parallel have an aggregate width of about one thousand miles. Nearly coincident, however, with the latitude of the head-waters of the Missouri, a change occurs in the character of this Cordillera region; it becomes comparatively strict and narrow, and runs to the 56th parallel or beyond, with an average width of about 400 miles only. This narrower portion of the Cordillera comprises the greater part of the province of British Columbia and consists of four main ranges, or more correctly speaking, systems of mountains, each composed of a number of constituent ranges. These mountain systems are from east to west, (1) The Rocky Mountains proper; (2) Mountains which may be classed together as the Gold Ranges; (3) The system of Coast Ranges sometimes improperly regarded as a continuation of the Cascade Mountains of Oregon and Washington Territory; (4) A mountain system which in its unsubmerged parts constitutes Vancouver and the Queen Charlotte Islands. This last is here actually the bordering range of the continent, as beyond it, after a submarine plateau of inconsiderable width, the bottom shelves very rapidly down to The Cordillera belt.

to the abyssal depths of the Pacific. The Tertiary coast ranges of the south are here entirely wanting. Between the second and third of the above mountain systems is the Interior Plateau of British Columbia. with an average width of about one hundred miles, a mean elevation of about 3,500 feet, and peculiar character and climate.

The Rocky Mountains.

The present report refers more particularly to a portion of the Rocky Mountains proper. This system of mountains has, between the 49th and 53rd parallels an average width of about fifty miles, which in the vicinity of the Peace River decreases to forty miles, the general altitude of the range as well as that of its supporting plateau at the same time becoming less. Beyond the Peace River region these mountains are known only in the most general and unsatisfactory way. The portion of the Rocky Mountains which has been explored is bordered to the eastward by the Great Plains, which break into a series of foot-hills along its base, and to the westward by a remarkably straight and definite valley, which is occupied by portions of the Columbia, Kootanie and other rivers, and is known to preserve its general direction and character for over six hundred miles.

Trend and width.

The general trend of that portion of the Rocky Mountains here particularly described,—between the parallels of 49° and 51° 30′—is about N.N.W.-S.S.E., but when more closely examined it is found to include three subordinate trends. That portion of the system, extending on the east side, from the 49th parallel to the South Fork of the Old Man River, has a general bearing of N. 35° W. Thence northward to the point at which the Highwood leaves the mountains, the general trend is N. 12°W., after which the bearing again becomes about N. 35° W., and so continues to the northern limit of the map. Notwithstanding the changes in general trend, the average width is preserved throughout with considerable constancy, though it becomes greater than usual in the north-and-south trending portion, where large Cretaceous infolds occur, as elsewhere more fully described. The constituent ranges and ridges conform very markedly to the varying directions above stated, and while these are most clearly shown by the outer eastern range, the three directions of trend are scarcely less evident on the western border. The least regular and most tumultuous portion of these mountains is that in the neighborhood of the 49th parallel.

The base-level of the Rocky Mountain range is much higher on the eastern than on the western side. On the east, as ascertained by taking the average level at which the larger streams leave the mountains proper and pass into the foot-hill region, it is about 4,360 feet. On the west, the average elevation of the Columbia-Kootanie Valley is approximately 2,450 feet. In consequence of this difference, the passes traversing the range have, (as first noted by Captain Palliser), a steep

and sudden descent to the west of the watershed in contrast to the more gradual slope to the east.

The foot-hills, though they might be regarded structurally as a portion of the mountains, being composed of rocks flexed and disturbed parallel to and contemporaneously with those of the mountains proper, differ much in their general appearance and character from them, and seldom equal even their outer and lower summits in height. The amount of disturbance in the foot-hills is not less than that found in the mountains, and in many places is even greater, the beds being often vertical, or even overturned, in transverse sections several miles in length. They are, however, composed of the Cretaceous and Laramie rocks, which, further east, in nearly horizontal and unbroken sheets, form the substructure of the Great Plains; while the mountains proper are composed of the older Palæozoic rocks which never appear at the surface in the area of the plains. To the less resistence to denudation which the newer and softer rocks have offered, must be attributed the inferior present elevation of the foot-hill region, and the comparatively rounded outlines of its hills and ridges, which are almost everywhere covered with vegetation. During the time intervening between the close of the Laramie and the earliest Miocene, a truly surprising amount of denudation must have occurred, of which in this region no geological record remains. Structure and origin of the foot-hills.

The average width of the foot-hill belt may be stated as about fifteen miles, and its eastern margin, where the sharp flexures abruptly subside, forms a line which is almost exactly parallel to the trend of the base of the mountains previously alluded to. The eastern base of the rugged and bare mountains coincides everywhere so closely with that of the Palæozoic rocks, that this geological line may be taken as defining also the boundary between the mountains proper and the foot-hills. The foot-hills region is characterized by series of long ridges, or hills arranged more or less definitely in linear series, the positions of which have been determined by the existence of zones of harder rock—generally sandstones. Between these ridges are wide valleys in which the smaller streams course, while the larger rivers, having their soures in the mountains, generally cut across nearly at right angles. Though very well marked south of the Old Man River, these ridges are there usually rather low, and the proportion of wooded country being quite small, the prairie may be said to spread up to the very base of the mountains proper. North of the North Fork of the Old Man, however, the hills and ridges grow higher and more abrupt, and the wooded areas become more considerable till, about the Highwood River and Sheep Creek, extensive forest areas, interspersed with tracts of burnt woods, render the base of the mountains well nigh inapproachable, except Character of the foot-hills. Foot-hills low to the south. Higher northward.

3

along the river-valleys. The greater height and roughness of the foot-hill region in the vicinity of the Highwood River, Sheep Creek and the Elbow River, is co-ordinate with an increased height of the base-level of the mountains, which here attains its maximum; the levels at which the Highwood and Elbow Rivers leave the mountains being approximately 4,780 and 4,800 feet respectively. The streams which issue from the mountains at the lowest levels are the South and Middle Forks of the Old Man and the Bow River. The two first may be considered together as occupying a structural break in the front of the range, and have a level at this point of little over 4,150 feet. The Bow River, but for its greater size and erosive power, which have enabled it to produce a great valley, would probably have at its exit from the mountains, a height as great as that of the Elbow or the Kananaskis at a corresponding point, but it actually crosses the outer range with an elevation 4,170 feet only.

Appearance of the foot-hill region.

Where the summits of the foot-hill ridges are not crested with outcropping ledges of sandstone, their outlines are generally rounded and flowing. The parallel valleys contain a deep, rich, black soil, and under the influence of a sufficiently abundant rainfall, the vegetation is wonderfully luxuriant. There are indications of a very palpable character that the southern foot-hills were at a time not very remote, much more thickly wooded than at present, and that the recurring fires have much extended the open country. Before many years have passed, the same influence will have produced great changes in the northern parts of this region, still thickly wooded, and districts now almost impenetrable from tangled forest and windfall will have become open pasture lands.

Few regions in a state of nature can compare with the southern part of the foot-hills in beauty. The long grassy slopes covered with an infinite diversity of wild flowers, the rivers fresh from their mountain sources, rapid, cold and clear, and the ever-changing views of the great background of mountains, combine to form a most attractive landscape.

Structure of the mountains.

As in most mountain regions (and here specially apparent on account of the strict parallelism of the rock-folding), the ruling feature of this part of the Rocky Mountains may be described as a system of parallel ridges, crossed nearly at right angles by a series of transverse breaks. These are abundantly evident, whatever their cause, which from a geological point of view is not very clear. On a larger scale, the plan of the foot-hills is repeated in the mountains, and some of the more evident breaks are continued quite through the foothills to the eastern plains, while in other parts of the foot-hills—as between the Middle and North forks of the Old Man—a series of similar

breaks is found traversing the foot-hills themselves, but not affecting the mountains. It is an interesting question, but one on which, as yet, we have scarcely sufficient evidence for decision, whether such transverse breaks are due to lines of comminuted fracture and shattering of rocks, or whether they represent portions of the older drainage-valleys of the axis of elevation, which, by drawing to themselves the waters of the smaller streams of the longitudinal valleys, have succeeded in maintaining their supremacy as drainage channels even to the present time, though the longitudinal valleys have become the most noticeable features. It appears highly probable that both causes have been concerned in their formation.

Two systems of valleys.

So far no evidence of extensive faulting has been discovered in connection with these transverse lines. In no case, however, in the region now described, does such a transverse break preserve its character so definitely across the whole breadth of the range as to form a direct 'pass' or practicable route of travel, though the North Kootanie Pass closely approaches this condition. The routes offering the greatest facilities for crossing the mountains, generally follow zig-zag courses, partly along the longitudinal valleys, and seek the lowest points at which to traverse the intervening mountain ridges. In consequence of this, the lengths of the various transverse passes are often considerably greater than the actual width of the mountains. In the following list, the known passes in this part of the range are enumerated in order from south to north, with the length of each measured along the direction of the trail from the eastern to the western base of the mountains. The altitude of each, at the watershed or main summit, is given in the second column.—

Routes across the mountains.

List of passes.

	Length in miles.	Elevation at watershed.
South Kootanie or Boundary Pass	66	7,100
North Kootanie Pass	48	6,750
Crow Nest Pass	56	4,830
North Fork Pass (1)	46	6,773
Kananaskis Pass	85	6,200
White Man's Pass (2)	70	6,807
Simpson Pass (3)	70	6,670
Vermilion Pass (4)	88	5,264
Kicking Horse Pass	104	5,300

(1). Measured from the Elk River Crossing in a straight line to the Kootanie Valley, the western continuation of this pass not having been explored.

(2). Measured up the Bow Valley on the east, and at the west end crossing the Brisco Range by Sinclair Pass.

(3). Measured up Bow Valley on the east, and across the Brisco Range in a direct line, by reported pass.
(4). The eastern and western ends of this pass are identical with the last.
(5). By the railway line, 111 miles.

It is probable that even within this district there are other passes across the watershed range beside those here named. The Indians, in the course of their hunting expeditions, travel on foot in every direction across the mountains, but designate as passes only the routes which are not too steep or rough for horses.

Character and importance of the passes. Most of the passes above enumerated cross subsidiary summits of some height west of the main watershed. The South and North Kootanie Passes have long been in regular use by the Indians, and both these, after descending into the Flat-head Valley, in the centre of the mountain region, cross a second high 'divide' between this river and the Kootanie Valley. The Crow Nest Pass was little used by the Indians, owing to the thick forest prevailing along parts of it, but it was some years ago chopped out, and rough bridges were thrown over some of the streams, to provide a route for taking horses and cattle eastward across the range. The North Fork Pass appears for the first time on the accompanying map, and was not known, except by Indians, till crossed by myself in 1884. The Kananaskis Pass was traversed by Captain Palliser in 1858, and has been much used by the Indians. The White Man's Pass probably derives its name from the circumstance of its use by emigrants in 1841 (see p. 10 B). Sir George Simpson in the same year, crossed the mountains by the pass to which his name is now attached. The Vermilion Pass has long been a much-travelled Indian route, and takes its name from copious chalybeate springs which deposit large quantities of ochre. The Kicking Horse Pass was little known, and scarcely used by the Indians, probably on account of the thickness of the woods and rough character of parts of the valley for horses.

Howse and Athabasca Passes. About fifty miles north of the last-named pass, and beyond the limits of the accompanying map, is the Howse Pass, and thence to the Athabasca Pass, a further distance of sixty-three miles, no practicable route is known across the axis of the range. In 1884 I learned from the Stoney Indians that a hunting party, having heard reports of abundance of game in the region, had during the summer tried every valley between the Athabasca and Howse passes, but had been unable to get their horses over, being repulsed either by impassable rocky mountains or by glaciers and snow-fields which filled the intervening valleys.

Constituent rocks of the mountains. The ancient crystalline rocks form no part of this portion of the Rocky Mountains, which is chiefly composed of Cambrian, Devonian

and Carboniferous strata, violently flexed and often completely overturned. The differences in resistence to denudation of these rocks are not on the large scale considerable, and the regions of greater and less elevation thus depend closely on the nature and volume of the folds of the component strata. The most important interruption to the uniformity of this part of the range is found in the fact that the folding has in several places been so extensive as to include large areas of Lower Cretaceous rocks, which appear, previous to the main era of mountain elevation, to have overlain this region in great volume. Wherever these rocks constitute considerable areas of the present surface, we find a partial repetition of the conditions obtaining in the foot-hills, characterizing tracts which are surrounded by ranges of limestone or other Palæozoic rocks. Where such areas are extensive—as in the region between the North Kootanie Pass, the Highwood River and the Elk—the neighbouring and intervening Palæozoic ranges, are, though still very prominent, owing to a lack of support and the more rapid and uniform wearing away of the softer Cretaceous rocks, of less elevation than elsewhere, and the general height of the mountain region is inferior. Where such softer areas are wanting, as near the 49th parallel and about the head-waters of the Bow River, the general altitude is correlatively increased.

Higher and lower areas.

Height and appearance of the mountains.

The culminating point of the Rocky Mountains is doubtless to be found about the 52nd parallel of north latitude, or between this and the 53rd parallel, where Mounts Brown and Murchison, occur with reputed altitudes of 16,000 and 13,500 feet respectively, and Mount Hooker, also reported to be very lofty. These heights, however, are not great in comparison with those found in some other mountain ranges, and those met with in the region here particularly described are even less. The height of the adjacent country, and the yet more considerable elevation of the drainage level within the area of the mountains, moreover, reduces the apparent magnitude of the range, and mountains rising more than 5,000 feet above the point of view are seldom encountered. The scenery is, therefore, not of the impressive magnitude of that met with in such mountains as the Himalayas, or even the higher portions of the Alps. It has, however, a character of its own, and what it may want in actual dimensions is compensated by its ruggedness and infinite variety, the mass of its broken escarpments and the height of its bare cliffs, which rise often over valleys densely filled with primeval forest. The contrast in respect to form is very marked between these mountains and those belonging to the Selkirk and Purcell ranges, on the opposite side of the great Columbia-Kootanie Valley. Along the eastern side of this valley, the outer range of the Rocky Mountain

system forms an almost continuous wall of bare and shattered, though not very lofty, limestone peaks. The Selkirk and Purcell ranges, on the contrary, begin to assume a rugged character only in the vicinity of the axis of the mountain system, while the flanking hills, for a number of miles back from their base, show gently swelling outlines, and are, as a rule, thickly covered with forest.

Irregular mountain region.

That portion of the mountains south of the North Kootanie Pass presents but little of the structural regularity elsewhere met with, and the characteristic parallelism of features appears to be obscured by a geological uplift which brings considerable areas of Cambrian rocks to the surface in the vicinity of the South Kootanie Pass. Whether connected with this uplift, or due to other causes, the parallel folding of the rocks of the mountains, elsewhere referred to, is not here well marked, or acute, and the beds for the most part lie at remarkably low angles. The eastern base of this part of the mountains is also anomalous in character, being, between Waterton Lake and the South Fork of the Old Man, cut by a number of small but deep valleys with north-east and south-west trends, which rise some miles back from the outer edge of the range and hold the tributaries of the Waterton River and the South Fork. The block of mountains bounded by the South and North Kootanie Passes, the Flat-head Valley and the eastern foot-hills is, in fact, peculiar in that it discharges its drainage nearly equally in all directions. Castle Mountain (S), the summit of which is evidently composed of massive and nearly horizontal beds of limestone, is one of the higher and more remarkable peaks of this group of mountains. The other central mountains are not known.

Mountains between North Kootanie and Kananaskis Passes.

Beyond the North Kootanie and Crow Nest passes, the parallel mountain ridges become well defined. The Livingstone Range, continued further northward by the Highwood Range, forms the outer ridge of the mountains, and extends with slight interruption for a distance of eighty miles, to the Elbow River. A second limestone ridge is formed by the Flat-head and High Rock Ranges, which lie nearly parallel to the first, and have like it a slight convexity eastward. The Elk Mountains continue this line to the sources of the Elbow, where the space between this and the outer range having become comparatively small is nearly filled by the intercalated Misty Range. Further west, the Wī-suk-i-tshak Range forms a third imperfect parallel, and beyond is the very rough and high range to the west of the Elk River, between which and the Hughes Range, bordering the Columbia-Kootanie Valley, a wide space remains unknown.

Mountains between Kananaskis and Vermilion Passes.

The mountain region between the upper part of the Elbow River and Kananaskis Pass on the south, and the Bow River and Vermilion Pass on the north, wants the wide Cretaceous valleys found in the part last

described, and is composed of from eight to ten main ranges, with but two wide intervening valleys—one running from the head of the Kananaskis to Spray River, the other holding the head-waters of the Kootanie. The parallelism of these ranges is not less well marked, but their continuity is frequently interrupted both by transverse valleys and by an echelon-like arrangement which subsists between them. Fisher's Range here constitutes the eastern front of the mountains. Behind it a second tier is formed by a somewhat irregular range, which ends in Pigeon Mountain on the Bow. The Opal Mountains and connecting elevations ending on the Bow in Mount Rundle, form a third range, while the Kananaskis and Goat Ranges, with Terrace Mountain, constitute a fourth. The Spray and Bourgeau Mountains are the best known portions of a fifth parallel, while a sixth runs southward from Pilot Mountain, but dies out before reaching the White Man's Pass. The Blue Mountains and connected mountains ending in Mount Ball on the Vermilion Pass, form a wide and somewhat irregular seventh range. Between this and the important ridge formed by the Mitchell and Vermilion Ranges, there are probably two short intercalated ranges, of which the ends are seen on the Cross River. The Brisco and Stanford ranges constitute the western elevation of the mountains, and are wider and more persistent than most of those above named.

Mountains North of the Bow River and Vermilion Pass.

North of the Bow River and Vermilion Pass, the parallelism of the constituent ranges, so far as known, is equally great, but the names Fairholme Mountains, Palliser and Saw-back Ranges are there applied to rather extensive blocks of mountains, the constituent ridges of which have not yet been mapped. The Bow Range and Waputtehk Mountains, cut across by the Kicking Horse Pass, constitute together a a very massive range, which to the west, in the vicinity of the pass, becomes broken up into rather irregular groups of mountains. The lofty Otter-tail Mountains are continued to the north-west by two ranges, the Van Horne Mountains and Mount Hunter, while the Beaver-foot Range (really a continuation of the Brisco Range) fronts on the Columbia Valley.

Relations of higher mountain regions to watershed.

As will have been gathered from the foregoing general description, no single ridge or system of elevations constitutes the watershed range in this part of the mountains, nor does the portion of the mountains characterized by the greatest connected areas of high mountain country and crowned by most of the higher peaks, coincide with it. A line following this most elevated region would probably run from the neighbourhood of Waterton Lake west-north-west to the vicinity of the Lizard Mountains, thence northward to the west of the Elk River, to latitude 50° 30', and thence north-westward, passing through the Blue Mountains and Bow Range. Only in the last-described portion of its length

would it be identified with the main water-parting. Therefore, other circumstances than the position of this line of greatest elevation must have operated in determining the watershed; or that which was originally the highest part of this mountain system is still marked approximately by the present position of the 'main divide,' but has since become relatively depressed by the more active progress of denudation. It is quite possible that the latter supposition is correct. The steeper pitch and consequent greater erosive power of the westward-flowing streams, with other minor circumstances not necessary here to detail, afford ground for the belief that the line of the watershed has, during the process of the denudation of these mountains, retreated eastward for a greater or less distance.

Actual position of the watershed. From the South Kootanie summit, the actual watershed runs north-westward to the north Kootanie summit, probably forming a very sinuous line, as it does not here appear to coincide with any single range. Thence it follows the Flat-head Range for some distance, but on the Crow Nest Pass is found to lie in a comparatively low tract several miles west of that range. Thence, for many miles northward, the High Rock Range forms a definite line of water-parting. At the northern end of this range it is quite probable that the watershed lies to the east of its axis, though this point has not been determined. It next follows the Elk Mountains for a few miles, crosses the wide longitudinal valley in which the Kananaskis and Elk head in a common, swampy tract, and after following the southern continuation of the Spray Mountains round the head of the Upper Kananaskis Lake, falls back on the White Man's Pass to the next range to the west. Thence, after following the Blue Mountain Range, it is found to the east of the main axis of elevation on Simpson Pass, after which it becomes identified with this axis in the Bow Range and Waputtehk Mountains. Regarded as the eastern boundary of the province of British Columbia, it presents on the map an undesirable sinuosity, but possesses a practical advantage in being always easily determined on the ground in each particular locality, and requiring no elaborate survey of system or land-marks to fix its position.

Most lofty mountains. In the region embraced by the map, Mount Lefroy (of Hector), with an altitude of 11,658 feet above the sea, appears as the highest peak. It is the most lofty of which any actual measurement has been made, but others may still be found with an equal or greater height. It is quite probable that the blunt summit a few miles north-west of Mount Lefroy, in the same range, and forming the centre to which the spurs seen on the south side of Kicking Horse Pass attach, is higher. The remarkable peak called Assiniboine Mountain, of which I estimated the height, as seen from a considerable distance, at 11,500

feet, may also prove to exceed Mount Lefroy when it shall be measured, and there are some very lofty mountains in the unexplored tract west of the Elk River, which have been seen only from high points east of the Elk many miles distant.

A number of mountains shown on the map are known, however, to exceed 10,000 feet in height, while whole ranges and groups of peaks in the district surpass 8,000 feet.

Escarpment-like mountains.

The type of mountain structure most extensively developed in this region is that of the escarpment, with cliffs or very steep slopes on one side, and long and comparatively light slopes on the other. The steeper slopes generally face eastward, in consequence of the prevalence of westward dips, though the conditions are reversed on the west side of the range. The ridges are very often composed of massive beds of limestone, and these lighter slopes are at an angle sometimes identical with the dip of the beds; in which case inclined surfaces of rock, almost as bare as the more abrupt, eastward-facing cliffs, are often formed. Among the more striking instances of this type of mountains may be mentioned, Prow Mountain, on the Red Deer, Mount Rundle and the range running south from it, and others in this vicinity, also part of the Highwood Range south of Mount Head. Mountains of this form are, however, numerous everywhere in this district. Where the mountain tops are formed of nearly horizontal beds of the massive limestones, as not infrequently happens, the easy disintegration of these rocks along jointage-planes, at right angles to the bedding, produces summits with very striking forms, of which the upper parts are almost sheer cliffs, often of very great height. The conspicuous, block-like summit of Chief Mountain is a good instance of this type, others are the Crow's Nest and Bee-hive Mountain, with summits resembling broken columns, and Castle Mountain, on the Bow River, with its long ranges of vertical, rampart-like cliffs. A later stage in decay of mountains of this type produces chimney- or spire-like peaks, such as are found running north from the Crow's Nest, at the eastern extremity of Castle Mountain (N), and in a very picturesque peak at the head of the short valley which joins the North-west Branch of the Old Man River near its head at the fall. The index-like pinnacle, at one end of Castle Mountain, of the southern part of the range, is another instance. When the limestone series has been turned completely on edge, as in the western ridge of the Saw-back Range, in the Opal Mountains and elsewhere, the limestones entirely lose their characteristic massive appearance and produce ranges with a very straight crest, but narrow, and with saw-like outlines.

Block-like mountains.

Serrated ranges

The rocks of the underlying quartzite series, though in themselves hard, are not in such thick beds as the limestones, and are, moreover,

Quartzite and slate mountains

very much shattered by innumerable jointage-planes. As a consequence of these conditions, the forms of the mountains composed of them are not so striking nor so much individualized. They tend to form systems of angular, steep-sided ridges, separated by V-shaped valleys, which radiate in all directions from the higher parts. If of inferior height, or when erosion has not proceeded so actively, they may become almost rounded in outline. The slate mountains on the Bow River, and the Van Horne Mountains on the Kicking Horse, may be mentioned as illustrations of these.

Unexplored region.

The largest part of that portion of the Rocky Mountains represented on the accompanying map which yet remains completely unexplored, is that alluded to as lying between the Elk River and the Kootanie. This region is known to be one of great difficulty, not only from its rugged, mountainous character, but from the fact that owing to its abundant rainfall, the forest growth is there particularly impenetrable. Judging from our experience elsewhere, however, I believe it would not on actual trial prove nearly so difficult as reported. It was not entered by us, merely because the time at our disposal was not more than sufficient for traversing the main routes, and for the delimitation of the more important Cretaceous areas in the region. The cause of its being avoided by the main trails is probably to be found chiefly in the position of the Elk River, which constitutes at all but its lowest stages, a well-nigh impassible barrier, being as a rule too deep to ford with animals, and too swift for rafting. In view of the gold-bearing character of Wild Horse Creek and the Bull River, both heading in this unexplored tract, it would appear to be one worthy of the attention of the prospector.

Normal conditions of drainage.

The transverse valleys, previously described as constituting one of the well-marked structural features of this part of the Rocky Mountains, are so numerous, that it would appear to be the normal condition for each of these to unwater a comparatively limited tract of the mountains. receiving as tributaries the streams from the longitudinal valleys. To such an arrangement the valleys of the several branches of the Old Man, together with those of the Highwood, Sheep, Red Deer, and several others, conform pretty evidently. In other cases, however, owing probably to causes explicable on grounds of geological structure, the longitudinal valleys have become the main water-ways, and collect the streams of a number of areas which drain toward them through smaller transverse breaks. Of this, the Elk River is the most remarkable example. and the determining cause in this case is evidently to be found in the existence of the long infold of the softer Cretaceous rocks which it follows. The upper part of the Kootanie River is another case in point,but the importance of the valley is there due to the existence of an anticlinal axis of Cambrian rocks, which is continued northward

Longitudinal intercepting streams.

in the Beaver-foot Valley. Both these streams eventually break across the intervening ranges to the west. The Flat-head Valley is another instance of the same kind, but the cause of its existence is not so obvious. It is worthy of note that all these large, intercepting, longitudinal streams flow southward.

The Bow Valley. The course of the Bow River in the mountains, is very remarkable. After first flowing in an anticlinal Cambrian valley, it turns eastward and breaks completely across the series of mountain-ridges which form the Saw-back Range. It then reaches an important Cretaceous infold, and after following it for a number of miles to the south-east, again turns nearly at right angles, and breaking through the outer ranges, reaches the foot-hills. It is highly probable that the Bow at one time flowed through the valley now occupied by Devil's Lake, the singular characters of which are elsewhere described, and that the change in its course took place either during or subsequently to the glacial period. Such a change might have happened in consequence of the more prolonged blocking of the Devil's Lake valley by glacier ice derived from the high mountains surrounding it. The only other instance which need be referred to of a now disused channel, which evidently at a former period carried a large stream, is that of the valley which opens at each end on the Spray River and runs to the east of the Goat Range.

Abandoned river-valleys.

Antiquity of the drainage-system. In so mountainous a region, such changes must necessarily be quite exceptional, as drainage channels once established would in general be very persistent. Evidence of the great antiquity and permanence of the channels of drainage is abundant. Except it were the complete blocking of valleys by masses of glacier ice, circumstances under which the larger streams would be diverted from the depressions they have now produced, are well nigh inconceivable, and most of the rivers appear to have simply re-occupied these old courses after the ice of the glacial period had passed away. The transverse valleys are supposed to be, geologically, the most ancient, as they are those for which least apparent determining cause can be found at the present day. A circumstance indicating their vast antiquity, is that the lowest summits between the tributaries of contiguous transverse valleys, are in several cases as high as, or higher, than those of the main watershed of the mountains in the same neighbourhood. A marked superiority once obtained by any of the larger streams is of course likely to be perpetuated and to increase at an accelerated ratio in consequence of the greater erosive power thus gained. The formation of such main water-courses as the Bow, Elk, etc., is probably due to such cumulative increase.

Lakes. The lakes found in or adjacent to this part of the mountains are not very numerous or important. The largest are the Columbia Lakes, the

character and origin of which are elsewhere spoken of. The upper lake is nine, the lower about eight miles in length, the width of each being in some places about a mile. Devil's Lake, ten miles in length, but narrow, has been referred to as probably occupying part of a former river valley. Trout Lake on the White Man's Pass is of the same character, but much smaller. The upper and larger of the Waterton Lakes, nine miles long, is pretty certainly held in by the accumulation of debris brought down by the Kootanie Brook, though perhaps also in part dammed by moraine material. In any case it certainly occupies the position once held by a glacier in the same valley. The lower Waterton Lake is probably also moraine-dammed. Bow Lake doubtless occupies the bed of a former extension of the glacier still existing at its head. Several smaller lakes such as that on the summit of the Vermilion Pass have evidently been produced by debris from tributary streams or torrents blocking up the valleys. Kicking Horse Lake flows westward over a lip of rock. It occupies part of the bottom of a wide valley transverse to the watershed range, which probably drained eastward before it became filled by glacial drift deposits in the vicinity of Stephen station. There are also a number of small lakes and pools which lie in cirques or occupy the upper ends of deep valleys heading in the mountains, and some of these may rest in true rock-basins of glacial origin.

Columbia-Kootanie Valley.

The Columbia-Kootanie Valley, bordering the Rocky Mountains on the west, has already been referred to as an orographic feature of the first importance. The portion of this valley included in the present report and map extends from the 49th parallel to the mouth of the Kicking Horse, with a length of one hundred and eighty-five miles. The eastern side of the valley is here formed by the escarpment-like western range of the Rocky Mountains, while the slopes on its western side are, as has already been stated, longer and lighter. The general direction of dip of the rocks of the first-mentioned range being eastward, this great valley may be considered as an exaggerated instance of the strike valleys elsewhere met with in this region. Indications are not wanting of fracture and disturbance in the rocks along the line of the valley, but it appears probable that it has been produced for the most part by the normal action of streams cutting along the basset-edges of the strata, and that as it has increased in depth, it has also changed its position laterally, moving to the eastward.

Its present anomalous character.

Active erosion is, however, not now in progress in this great valley. Like most of the larger valleys, it is evidently of pre-glacial origin, and is deeply filled with drift materials. We cannot even certainly tell in which direction it discharged in pre-glacial times, though it was probably southward. The present condition of the valley

in regard to its drainage is both peculiar and anomalous. The Columbia River, finding its furthest source in the Upper Columbia Lake, flows thence through the second or lower lake northward for about one hundred and seventy miles to its great bend at the mouth of the Canoe River, while the Kootanie River enters the same wide longitudinal valley nearly abreast of the head of the Upper Columbia Lake, and flowing southward, eventually joins the Columbia at a much lower point. The Kootanie, where it enters this great valley through a gorge in the western range of the Rocky Mountains, is already a large stream, which can be forded at low water only. It is very rapid, and its whole course as far as and beyond the 49th parallel is swift and interrupted by numerous rapids or 'riffles.' The Columbia, owing to the considerable number of streams and springs which feed the upper lake, may rank as a river where it leaves that body of water, but, in contrast with the Kootanie, is a stream with very gentle current, and may even be called sluggish in many places northward to the mouth of the Kicking Horse, where it passes beyond the limit of the present map. The amount of fall of the Kootanie River from the place at which it enters the valley to the forty-ninth parallel, is over 500 feet in a distance of eighty-five miles in a straight line; that of the Columbia, from the Upper Columbia Lake to the mouth of the Kicking Horse, is approximately, 200 feet, in a distance, similarly measured, of eighty-three miles. The distance between the head of the lake and the nearest point on the Kootanie River, is about a mile and a half, the intervening country being a flat terrace, and the water of the Kootanie being actually higher than that of the Columbia Lake by a few feet. The cause of this singular relationship of the two rivers will be referred to later. Courses of the two rivers.

The Columbia-Kootanie Valley, as it now exists, has an average width of about five miles between the steep slopes of the mountains bounding it, and though in some places much wider, it is in the main, a great flat-bottomed, parallel-sided trough. Except in the vicinity of the steeper bordering mountain-slopes, solid rock seldom appears at the surface, and then generally as bosses or isolated masses rising to an inconsiderable elevation above the detrital deposits, by which it has been filled, which are evidently of great thickness. Regarded as a whole, however, the valley is widest in its southern part, and this constitutes one argument in favour of its original southern outflow. As an exception to the general character above given may be mentioned the existence of two ridge-shaped, longitudinal elevations which occur between latitudes 50° 30′ and 51°. These lie in the centre of the valley, west of the present position of the Columbia River. Great width of the valley.

The detrital deposits which now floor the valley are markedly terraced at several different levels, which do not appear to preserve any

Detrital deposits in Columbia-Kootanie Valley.

great constancy in relative height. In a number of places, however, extending all the way from the 49th parallel to the northern edge of the map, collections of irregular mounds and ridges occur, which are almost certainly morainic in character, and very frequently the terraced surfaces are broken by groups of projections of the same class, more or less degraded by water action, and evidently partly buried in the later horizontal deposits. These, with frequent intercalations of sand and gravel, are largely composed of fine, pale silts, which show a tendency to form vertical bluffs along the streams, and are in some places almost pure white. Remarkable examples of this silt occur on the Columbia about three miles below the lower lake, on the Kootanie between the mouth of Tobacco River and the Elk, and elsewhere. Similar silts, forming probably part of the same formation, may be traced some distance up the Kicking Horse Valley, and in the valley of the lower part of the Wigwam, in which localities they reach a height of about 3,500 feet above the sea-level.

Secondary axial trough.

Since the terrace-forming epoch, however, a wide, depressed, flat-bottomed trough has been formed in the detrital deposits along the centre of the great valley, and the Kootanie and Columbia rivers, though in places impinging upon the edges of the higher terraces, in general follow a more or less tortuous course in the bottom of this secondary trough, which varies from about half a mile to a mile or more in width, and neither of these streams normally flow upon the actual rocky bed of the great valley. As elsewhere stated, there is reason to believe that deposits of later Tertiary age (probably Miocene) occupy part of the bottom of the wide valley of the Kootanie beneath the detrital deposits.

Origin of this great valley.

It would thus appear that the origin of the Columbia-Kootanie depression must be sought at a remote period of great or very long-continued erosion subsequent to the era of mountain elevation at the close of the Laramie, and the facts are in favour of the belief that the river producing it flowed to the southward. In later Tertiary times there was already a great valley, in which, owing to some change in relative elevation, stratified deposits were formed, and during the glacial period a portion of the ice accumulating on the adjacent ranges discharged southward by this valley. On the withdrawal of this great glacier, morainic accumulations were formed along its retreating edge and by smaller glaciers, at the mouths of the lateral valleys. At this time, or not long thereafter, owing to some combination of circumstances which we need not here pause to discuss, the valley was flooded to a considerable depth, and the white silt deposits—the material of which was directly due to the action of glaciers still existing in the neighbouring mountains—were laid down, the coarser intercalated

beds being doubtless produced near the mouths of lateral streams during times of flood.

Post-glacial southward drainage of valley.

When the body of water in which the white silts and associated deposits were formed was eventually drained, it is very clear that the river which then occupied the great valley again flowed southward, and produced the axial trough by erosion of the detrital deposits flooring the valley. The direction of the flow is well shown by the delta or 'fan' produced at the mouth of Dutch Creek, at the north end of the Upper Columbia Lake. This fan has been largely formed by the erosion of the white silt terraces, across which the stream flows near its mouth, and is quite lop-sided, tailing off to the southward in the direction of the flow in the main valley, while at a still later date the stream has cut a shallow gorge in the material of its own old delta deposit. Had the relative levels remained unaltered, is is uncertain whether the southward flow of the drainage of the valley would have been sufficient to maintain an uninterrupted waterway—as is still the case in that portion of the valley occupied by the Kootanie. The great quantities of coarse detritus brought in by the lateral streams would have a tendency, by interrupting this flow at various points, to produce a series of long lakes. The actual exceptionally light slope of the portion of the valley occupied by the Columbia, however, with the fact that the flow is now northward instead of to the south, favour the belief that a change in level occurred, by which the northern part of the district was relatively lowered, and that this, in conjunction with the great deposit formed by the Kootanie at the place at which it enters the valley, determined the present position of the watershed between the two streams, and reversed the direction of flow in that part of the valley now occupied by the Columbia. The Columbia lakes evidently occupy portions of the axial trough in the drift deposits which have been subsequently dammed off by the deposits of smaller lateral streams. From the lakes northward, all the way to the mouth of the Kicking Horse, the Columbia pursues a tortuous course through a series of morasses and lakelets which occupy this axial trough, the immediate borders of the river being generally marked by raised parallel banks supporting poplars, willows, and other trees, and separating the stream from the bordering swamps and ponds which render it in most places well nigh impossible of approach. The Kootanie, on the contrary, though flowing in the opposite direction in the continuation of the same axial trough, is bordered on alternate sides by grassy or partly wooded flats, which, though in places swampy, are frequently dry, or flooded only during periods of exceptionally high water.

Probable lowering northward.

Determination of position of watershed.

Glaciers and snow-fields.

Throughout the whole of this mountain region large patches of perennial snow are frequently met with at elevations surpassing 6,000 feet, and on northward slopes, and in retired valleys at lower heights. There are even some rather extensive snow-fields, but no large connected portion of the mountains rises to such a height as to show a well-marked snow-line. In the higher mountains near the forty-ninth parallel, masses of hard snow and ice exist which might be denominated glaciers, but further north, true glaciers occur, with all the well-known characters of those of the Alps and other high mountain regions. Such glaciers may be seen on the North Branch of the Kicking Horse, at the heads of the lakes forming the sources of the Bow, at the head-waters of the Red Deer and elsewhere, and are fed by snow-fields, the areas of which have not been accurately mapped, but must in some cases be very extensive.

At altitudes exceeding 6,000 feet, snow falls more or less frequently in every month in the year, and toward the first of October it may be expected to occur even in the lower valleys within the mountain region.

Differences in rain-fall.

In regard to precipitation, the circumstances differ remarkably in the different portions of this comparatively limited tract of mountains, the rain-fall being small in the Columbia-Kootanie Valley, heavy on the adjacent western slopes of the range, and again inconsiderable on the eastern slopes. The Selkirk and Purcell ranges, to the west, constitute a region of heavy rain-fall, and the position of the Columbia-Kootanie Valley in their lee, with reference to the prevailing westerly currents, explains the dry character of its climate. Meeting the western slopes of the Rocky Mountains proper, these air-currents are still sufficiently laden with moisture to give rise to the abundant precipitation of that region, but on passing still farther eastward, beyond the summit elevations, the conditions are unfavourable to further rain-fall. Superimposed, however, on these main features is a tendency to greater rain-fall toward the north, which is especially noticeable—whether from an increased elevation of mountain-barriers to the west or other cause—in comparing the conditions in different parts of the Columbia-Kootanie Valley.

Recent increase in rain-fall.

Evidence of a remarkable character has been found, which tends to show that a somewhat rapid increase in the total annual precipitation, has taken place during late years, and deserves to be recorded here. The evidence referred to is that afforded by the abnormal height of small lakes, without outlets, occurring in regions characterized by moraine hills. These serve as natural gauges, but instead of measuring the actual rainfall give a result, dependent on this and the counteracting effect of evaporation. The abnormal character of the rise of the water in these lakes is shown by the facts that it has killed a belt of trees, some of large size, and at least fifty years in age, along parts of the

margins of some of these lakelets. Both the Douglas fir and the yellow pine—the latter, never naturally growing even in damp soil,—have been found in numbers thus killed. The condition of the trees shows that they have been killed within a few years, and their size indicates that the waters of the lakes in question have not been for any considerable time during a period of fifty years or more, at the present high level. These observations were made both in 1883 and 1884. The lakelets observed to be so affected were numerous and scattered over a belt of country along the western part of the range for a length of about 140 miles; three of the principal districts at which such facts were noted being the Tobacco Plains, the Kootanie Valley between the Lussier River and head of Columbia Lake, and the upper valley of the Kootanie near the mouth of the Vermilion.

Heavy floods in 1884.

I noted also of the Columbia Valley south of the mouth of the Kicking Horse, in August, 1884, that most of the small streams coming from the mountains to the east showed marks of excessively heavy flood-water in the earlier part of the same year. This evidence was of such a character in relation to trees of great age which had been undermined, and belts of wood through which the water had rushed with devastating force, that I was led to believe that no such flood could have occurrred for fifty or a hundred years previously. New channels cut out in old fan accumulations, revealod also layers reddened by forest fires, which must have occurred centuries ago, showing that destruction of the forest by fire was even then in progress. It may be added here that evidence of the same nature with regard to very old forest fires, was noticed in railway cuttings on the Kicking Horse Pass, and also in one place on the Bow River, where modern forests, at least a hundred years in age, were growing above the reddened layer, still holding pieces of charcoal, which evidenced the destruction of a former growth.

Ancient fires.

Vegetation an index of climate.

The character of the vegetation is the most important index of climate, and within limits in latitude so resticted as those of the region at present considered, the influence due to position on the earth's surface may almost be disregarded.

Vegetation of different districts contrasted.

In the region here described, the total annual precipitation is doubtless least in that part of the Columbia-Kootanie Valley near the 49th parallel, which is known as the Tobacco Plains. Much of the surface is there open, covered with bunch-grass and dotted with open groves of yellow pine (*Pinus ponderosa*), interspersed with the western larch (*Larix occidentalis*) and Douglas fir (*Pseudotsuga Douglasii*). While drought-loving plants such as *Purshia tridentata*, several species of *Artemisia*, the low-growing cactus, *Bigelovia graveolens* and *Balsamorhiza sagittata* abound. Northward, in the valley, these forms (with the

exception of the Douglas fir) gradually disappear. The western larch and yellow pine cease abruptly at the bend of the Upper Columbia Lake, and beyond this point, the shrubby and herbaceous plants enumerated are found only sparingly on dry slopes. The open woods characteristic of the part of the valley occupied by the Kootanie, are also replaced by denser forest, of which the black or scrub pine (*Pinus Murrayana*) and Engelmann's spruce (*Picea Engelmanni*) form a large part. Near the Columbia lakes and southward, irrigation is necessary for the growth of crops, but where this has been attended to, excellent results are obtained. Cultivation has so far been attempted on a limited scale, and in a few spots only, but mountain streams available for purposes of irrigation are, fortunately, abundant, and though much of the soil in this part of the valley is rather light, it will eventually become of some importance from an agricultural point of view, its lower altitude and consequent less prolonged and rigorous winter being in its favour.

Region requiring irrigation.

In the Flat-head Valley, the character of country described as occurring on the Kootanie is repeated to some extent, but in a less pronounced way, and a few miles north of the 49th parallel the valley becomes blocked by dense forests.

Eastern slopes.

On the eastern slopes of the mountain region, and particularly in the lower valleys of the foot-hills, and those traversing this part of the mountains, these conditions are again to some extent repeated; and even within the outer range, rather extensive dry prairie-patches and slopes covered with bunch-grass are found in the lower parts of the depressions of the various passes. Neither the western larch nor the yellow pine, however, re-appear on this slope, and the Douglas fir. though abundant in the foot-hills and as far east as the Porcupine Hills, does not climb many hundred feet up the mountain-slopes, and is wanting in all the higher valleys.

Characteristic trees and plants

The tree most characteristic of the valleys on the western well-watered slopes of the range is the western cedar, or arbor-vitæ (*Thuya gigantea*). This tree, though found only in a few places to the north, in the part of the Columbia-Kootanie Valley included in the present report, occurs in greater or less abundance in the lower part of all the mountain valleys opening westward, from the Kicking Horse to the 49th parallel, but was not anywhere observed to the east of the watershed. In the southern part of the district, the bracken (*Pteris aquilina*, var. *lanuginosa*), occurs in the same valleys. *Pachystima myrsinites*, a low, evergreen shrub, is very generally found in the same districts with the cedar, but flourishes as an undergrowth in woods and valleys even higher and cooler than those in which the cedar grows. It is scarcely ever found east of the watershed, and though a rather incon-

spicuous plant, is specially worthy of mention from the constancy with which it appears everywhere in British Columbia as a characteristic mark of a cool, moisture-laden atmosphere. The devil's club (*Fatsia horrida*), thriving in conditions of still greater moisture, was observed only in one place on the Kicking Horse (near the mouth of Porcupine Creek), in The Gorge of the Vermilion, in the deep valley of the Elk where that river breaks through the outer range, and in the Sinclair Pass—all retired and shaded spots on the west slope of the mountains. The western white pine (*Pinus monticola*) is found on the western side of the range, but never in large groves, and is confined apparently in the Rocky Mountains to the southern part of the district. *Pinus flexilis* occurs sparingly along the Bow River in the foot-hills and in the eastern parts of the valley of the South Kootanie and other passes. The cottonwood (*Populus trichocarpa*), balsam poplar (*P. balsamifera*), aspen (*P. tremuloides*), and birch (*Betula papyrifera*), occur along valleys on both sides of the range. The western birch (*B. occidentalis*) was observed on both sides of the range, but not within the mountains. The rowen (*Pirus Sambucifolia*), sparingly in one or two places.

Most abundant forest trees.

By far the greater part of the forest growth, however, of this portion of the Rocky Mountains is composed of Engelmann's spruce and the black pine. These are equally abundant and characteristic in all parts of the range, and in cool and sub-alpine localities become mixed with the western balsam spruce (*Abies subalpina*), which often forms extensive groves. More strictly Alpine in habit is the white-barked pine (*Pinus albicaulis*); and Lyall's larch (*Larix Lyallii*) abounds only at the upper limit of arboreal growth. It appears with the greatest constancy at an elevation of 7,000 feet, which may be considered as the timber-line, as about this height, even in localities otherwise well suited for the growth of trees, they cease to be able to maintain themselves, the slopes above supporting only low alpine and boreal plants. When the leaves of this little larch begin to turn yellow, in September, its zone of growth in some places may be traced by this colour with the regularity of a contour-line along the higher mountain slopes.

Plants collected

It was originally intended to include as an appendix to this report a list of plants collected in this part of the mountains, but during the summer of 1885, Professor Macoun visited that part of the region near the line of the Canadian Pacific railway, and procured much more extensive collections than I had been able to make in connection with my geological work. References to the species obtained are given in his Catalogue of Canadian Plants (now in course of publication), rendering any attempt at a complete enumeration of the plants

Species confined to southern mountains.

here unnecessary. Professor Macoun, however, informs me that a considerable percentage of the plants obtained by myself in the South and North Kootanie passes and mountains adjacent to them, are not met with in the part of the range in which he has collected, a number of mountain forms apparently not extending more than a short distance northward beyond the 49th parallel. This circumstance is probably explained by the greater humidity of the northern region, in connection with the partial break in continuity of the higher eastern ranges, which occurs about the head waters of the Old Man River. *Xerophyllum Douglasii* is a remarkahle case in point, this plant being quite conspicuous in the South Kootanie Pass, but never found north of the Crow Nest Pass.

Trees characteristic of climate.

As differences in the composition of the forest growth of the various parts of the mountains form the most conspicuous indications of the different climatic zones, it may be useful to recapitulate the relative order in which the more abundant and constant trees met with in this region, naturally follow in this regard. This order is as follows.—

Larix Lyallii (Lyall's larch). Strictly Alpine.

Abies subalpina (Western balsam spruce). Alpine and sub-alpine, and extending downward to the higher and cooler valleys.

Picea Engelmanni (Engelmann's spruce) and *Pinus Murrayana* (black pine). Sub-alpine and extending downward.

Thuya gigantea (Western cedar). West slope only.

Pseudotsuga Douglasii (Douglas fir). Lower valleys on both slopes.

Larix occidentalis (Western larch). Base of mountains on the west.

Pinus ponderosa (yellow pine). Base of mountains on the west.

Deducting from this list *Thuya gigantea*, which appears to require a special degree of moisture in addition to other conditions, the order of enumeration proceeds from those trees tolerant of greatest cold and least warmth of summer temperature, to those which, though able to endure considerable winter cold, require a greater summer heat.

Destruction caused by forest fires.

Notwithstanding the evidence previously mentioned of the occasional occurrence of forest fires in ancient times in these mountains, it is only within the historic period for the region (probably not before the beginning of the century) that such fires became common, and during the past few years their frequency has increased in a greatly accelerating ratio. The effect of such fires is most disastrous. Large quantities of valuable timber are destroyed and whole regions become so blocked with tangled burnt woods and wind-fall as to be practically inaccessible, while the fine mountain scenery is seriously marred. These destructive fires in most cases arise through sheer carelessness or

wantonness and the most stringent measures should be taken to prevent them before it is too late. As the class of persons most careless in this respect is generally that least desirable to retain in any country, the authorities would find the respectable portion of the community in full sympathy with them in any measures adopted to check this evil. It is often stated that the Indians are responsible for much of this destruction, and it is doubtless true that since they find the whole region in process of being ravaged by fires which they can not prevent, they have become more careless than before. They would not, however, willingly destroy their own hunting grounds, and the best evidence of their care is found in the fact that, while along the North Kootanie Pass, (which so far has been scarcely used, except by the Indians,) the woods are generally unburnt, those in the vicinity of the parallel Crow Nest Pass, which has now been for a few years a route used by whites, are entirely destroyed and represented only by bleaching or blackened trunks.

Geological and General Description of the Region.

Mountains in the Vicinity of the Forty-ninth Parallel and near the South Kootanie Pass.

In treating of the geology and general features of this part of the mountains, as far west as the mouth of Akamina Brook, where my work in 1874, in connection with the Boundary Commission, may be said to have terminated, the description given in the Geology and Resources of the 49th Parallel will be in part quoted, with such additions as subsequent investigation render necessary. As already stated in the preliminary portion of this report, the South Kootanie Pass* was traversed in 1858 by Captain Blackiston, who was originally attached to Captain Palliser's expedition. He gives a map and profile of it in his report to the Imperial Government,† but has not furnished any geological notes. Mr. H. Bauerman gives some geological indications for this pass which will be found in his report, published for the first time in the report of the Geological Survey for 1882-84, together with some explanatory notes by the writer. **Previous explorations.**

Where intersected by the 49th parallel, the Rocky Mountains differ considerably in geological character from their northern extension, so far as included in the accompanying map. On this line the eastern **Character of mountains near 49th parallel.**

* Named the Boundary Pass on some maps, and also, from an alternative name of the Tobacco River in the Kootanie Valley, Grave Creek Pass.

† Further papers relative to the Exploration under Capt. Palliser, &c., 1860.

face of the range is very definite and wall-like, and in following the South Kootanie Pass, the rocks of the Cretaceous are not found to re-appear within the mountain region. Further north, particularly about the sources of the Old Man River, as first observed by the writer in 1881, the flexures of the rocks are such as to include long troughs of Cretaceous rocks, which divide the mountains into several well-defined subsidiary ranges, as fully described in connection with the northern passes. The rock exposures in the vicinity of the South Kootanie Pass are also particularly comprehensive and clear, rendering it possible, even with cursory examinations such as those of 1874, to correctly outline the main sub-divisions of the Palæozoic rocks. A remarkable spur or echelon range of the mountains, however, almost exactly coincides with the position of the International boundary line. Of this the remarkable peak known as Chief or Chief's Mountain* is the most prominent point, and though placed on Palliser's map on the boundary line, proved, when that line was accurately defined, to be nearly five miles south of it. The line, however, strikes into the hills and abrupt ridges surrounding its northern base, and then crossing the narrow valley of the Upper Belly River, passes over the Wilson Range, and bisects Waterton or Chief Mountain Lake, which lies at the foot of the principal range. The line thus runs for about fourteen miles through an outlying hilly and mountainous country, which by a detour of a few miles to the north may be entirely avoided, and waggons brought to the north end of Waterton Lake without difficulty.†

Remarkable spur.

Waterton Lake.

Waterton Lake‡ is the source of the river of the same name which runs northward to join the Belly. It is separated, by a rocky spur of Sheep Mountain, into two parts, of seven and two and a half miles respectively in length. The first or upper portion is almost entirely surrounded by high and rugged mountains, while the northern part, making a right angle with the former, lies along the base of Sheep Mountain, and is bordered by low land to the north. A river of about a mile in length, leads from the lower end of the lake to a third expansion, of about two miles in length, which is surrounded by low hills only. The average width of these lakes is about three-quarters

* *Nina-stokis* of the Blackfoot tribes. Doubtless the same with "The King" of Arrowsmith's map of 1795.

† In the Explorations and Surveys for a Railroad Route from the Mississippi River to the Pacific Ocean, Vol. I., p. 549, Mr. James Doty, in his report of an exploration northward, from Benton along the base of the Rocky Mountains, in 1854, describes as Chief Mountain Lake a lake which may be that at the head of the St. Mary River. It is certainly not the Waterton or Chief Mountain Lake of later maps. From his description it appears almost certain that the river, which he followed northward to about latitude 49° 30′, was that now known as the St. Mary.

‡ Named *A-kwote-katl-nam* on the map of the first Boundary Commission.

of a mile; the water is deep and clear,* and the scenery in the vicinity is not excelled in grandeur and beauty by that of any part of the mountains.

General section

The rocks exposed in the mountains near Waterton Lake, and in the adjacent portion of the South Kootanie Pass, embrace the greater part of the section represented in the entire region. The total thickness of the beds here shown, was estimated, in 1874, at 4,500 feet; and though this must be regarded as an approximation only, it is probably not far from the truth. The local section is thus given in my previous report, in descending order, the supposed age of the various portions of the series being added.—

Probably Triassic or Permo-Triassic.

H.—Fawn-colored flaggy beds, seen only at a distance, but probably composed of magnesian sandstones and limestones. 100 *feet.*

G.—Beds characterized by a predominant red colour, and chiefly red sandstone, but including some thin, greyish beds and magnesian sandstones. The whole generally thin-bedded, though sometimes rather massive. Ripple-marks, etc. Weathers to a steep rocky talus where exposed in the mountain sides. Passes gradually down into the next series. 300 *feet.*

F.—Fawn-colored, flaggy beds of magnesian sandstone and limestone. Some red sandstones occur throughout, but are especially abundant toward the top. Apparently a continuation upward of the limestone D, and only separated from it by the trap outflow. 200 *feet.*

E.—Amygdaloidal trap; (Diabase) dark-colored and hard. 50 *to* 100 *feet.*

Carboniferous and Devonian.

D.—Compact bluish limestone, somewhat magnesian, and weathering brownish. This forms some of the boldest crags and peaks of the mountains, and rests unconformably on Series C. 1,000 *feet.*

Cambrian.

C.—Sandstones, quartzites and slaty rocks of various tints, but chiefly reddish and greenish-grey; the individual beds seldom of great thickness, and the colour and texture of approximate beds rapidly alternating. In this series occurs a band of bright red rocks of inconstant thickness, also two or more zones of coarse magnesian grit. 2,000 *feet or more.*

B.—Limestone, pale-grey, cherty, and highly magnesian, hard, much altered and weathering white. It includes at least one band of coarse magnesian grit, like that found in the last series, which weather, brown. 200 *feet.*

A.—Impure dolomites and fine dolomitic quartzites; dark purplish and grey, but weathering bright brown of various shades. 700 *feet or more.*

* Capt. J. F. Gregory states that at a distance of 300 yards from the west shore, where intersected by the 49th Parallel, he was unable to reach bottom with a line 300 feet long. Capt. Gregory gives a detailed map of the shores of the lake in his report. Survey of Northern Boundary of United States.

Rocks near Waterton Lake.

Disregarding for the present the eastern outlying mountains above referred to, I shall describe the rocks seen in the vicinity of Waterton Lake. The lake is at an elevation of about 4,245 feet above the sea-level. The mountains surrounding it are often 8,000 feet above the same datum, and, like most of those in the eastern part of the range, are singularly bare and rocky and afford fine sections, even as viewed from a distance. They form a number of high ridges, which, on both sides, abut nearly at right angles on the lake shores, and are separated by deep intervening valleys. These ridges are as a rule capped by the massive limestones of series D, which are nearly horizontal, and rest upon the part of the Cambrian series which in the preceding table has been denoted by the letter C. At The Narrows, where the lake makes a bend, both shores are composed of rocks of series A, which appears to be brought to the surface by a low, irregular anticlinal flexure which crosses the lake in a north-west and south-east direction. The dolomitic rocks, which, for convenience of reference, have been denoted by the letter A, present a very remarkable appearance in the bare mountain sides, from the peculiarity of the tints assumed by them on weathering, which are for the most part bright reddish and yellowish browns, and alternate in broad belts according with the stratification. The bedding is very regular, and is marked, besides the difference in tint, by the erosion of some softer layers composed of thin, flaggy beds, which alternate with massive, compact layers several feet in thickness. The fracture of the more massive portions is conchoidal, with a dim lustre, and the colours of freshly broken surfaces are much less marked than those of the exterior, varying from light to dark grey, dull purplish and, in some cases, pale greyish pink.

Series A.

The structure of the rock is generally very close and fine, and from the preponderance of sedimentary matter, it frequently resembles more a hardened argillite than a true dolomite. It does not effervesce in cold dilute acid, but on heating gently, a brisk action is induced, and when the whole of the calcareous and magnesian matter has been removed, there remains a coherent though tender mass composed of argillaceous and siliceous particles. The exposed surfaces are generally decomposed to a small extent.

Of these rocks, at least seven hundred feet in thickness is exposed. They are well shown at the cascade* on the western shore of the lake, but to the south soon dip out of sight, the overlying beds coming down to the water-level. In 1874, and again in 1883, careful search was

* One mile from The Narrows. Called Cameron's Fall on plate opposite p. 312, in Survey of Northern Boundary of United States.

made in these rocks and also in the higher members of the Cambrian of this vicinity for fossils, but without success.

Resting directly on these peculiar dolomites is a very massive bed of limestone, also dolomitic, which forms a prominent feature from the chalky-white aspect of its weathered surfaces. It is designated by the letter B, in the general section previously given, and is about two hundred feet in thickness. It includes at least one well-marked band of coarse magnesian grit. The limestone, on fresh fracture, is of a pale grey colour, very close-grained and compact, and breaks with a splintery fracture, the original planes of deposition being almost entirely lost. Some layers are exceedingly cherty, the silicious matter being in places aggregated into well-defined nodules, but more usually disseminated, and forming an irregular skeleton, which gives to some weathered surfaces an exceedingly rough appearance. With acid, the rock scarcely effervesces in the cold, but on heating is rapidly dissolved, leaving a comparatively small amount of residue, which, under the microscope, seems not to be of a detrital nature, but to bear the form of minute concretions produced by the rearrangement of the silica. This limestone appears to be perfectly conformable with the rocks of series A and C, below and above it; constituting, in fact, merely a subordinate portion of this great Cambrian formation. Series B.

The rocks designated by the letter C, which overlie the last, are well exposed in the bare sides of the mountains on both shores of the northern end of Waterton Lake. On the east side they form a great portion of the west side of Sheep Mountain,* while to the west a mountain, rising about 4,000 feet above the lake and extending to the entrance to the South Kootanie Pass, is almost entirely composed of these beds, which have there been subjected to violent flexure. As a whole, this division of the section may be described as consisting of quartzites and hard quartzose sandstones, slates and shales; and its most remarkable feature is the rapid alternation of beds differing in colour and texture. Various shades of green, purplish-brown, red, and white are most prevalent. Series C.

In the almost vertical western side of Sheep Mountain, the total exposed thickness of beds of series C, must be about 2,000 feet. These rest directly on the limestone B, and are overlain by the limestone series D, the latter resting with evident unconformity on them. This unconformity is shown very clearly by the existence of a thick belt of bright red rocks, forming a part of series C, which is observed to run out altogether beneath the upper formation at one end of the mountain. Sheep Mountain.

* *Referred to as* Mount Wilson in the Geology and Resources of the 49th Parallel. It has since become known locally as Sheep Mountain, and the former name is perhaps more appropriately applied to the entire outlying range of which this peak forms a part.

6

Section in Sheep Mountain.

In 1881, Mr. R. G. McConnell, then acting as my assistant, ascended Sheep Mountain and measured the following section on its northern side, including part of the capping beds referred to the Devonian or Carboniferous limestone series (D) and a considerable portion of series C. The section is as follows in descending order:—

		FEET.
1.	Greenish-white, rather coarse-grained sandstone, moderately compact, in beds 3" to 1′ thick	45
2.	Greenish-white sandstone, weathering to a light yellowish colour, in beds 1" to 3" thick. Rather compact	30
3.	Greenish shales	70
4.	Red shales	20
5.	Green shales	15
6.	Greenish sandstones	20
7.	Light-greenish shales, very hard, and passing into quartzite in some places	80
8.	Yellowish sandstones, somewhat flaggy and ripple-marked	60
9.	Light-yellowish sandstone in beds 1′ to 2′ thick, alternating with thin beds of dark shale	85
10.	Drab-coloured limestone in beds 1′ to 2′ thick, greatly flexed in some places, conformable with beds above, but unconformable with rocks below	355
11.	Green shales, schistose in places, alternating with occasional beds of coarse, grey sandstone, some of the upper beds reddish	75
12.	Bright red shales, holding occasional beds of greyish and reddish sandstone, greenish shales and jaspery conglomerate, some beds of sandstone ripple-marked	700
13.	Greenish and reddish shales alternating with some grey sandstone	300
14.	Fine-grained, greenish-white sandstone, weathering light yellow, some of the beds very hard and passing into quartzite 100′ or more	100
		1,955

The beds from the summit to No. 10 inclusive are referred to series D. The appearance of so great a thickness of sandstones and shales with the limestone series is exceptional, though sandstones and quartzites of considerable thickness are found in association with it in some other parts of the mountains.

Wilson Range.

The outlying or counterfort range, situated to the east of Waterton Lake, and designated the Wilson Range, has a width, from west to east, between the lake shore and the upper part of the Belly River, of seven miles. Its western side and north-west angle is Sheep Mountain. Several of its summits and ridges, a short distance south of the 49th parallel, reach 9,000 feet in altitude, and its highest peak, situated about three

miles south-east of the upper end of Waterton Lake, reaches a height of 10,535 feet above the sea.* As viewed from the north, the front of the Wilson Range is chiefly composed of the rocks of series C, in which the bright red band, before described, is conspicuous in several places. The central and higher parts of the range are of the limestone and associated rocks of series D. Rocks differing in appearance from the rest, and apparently brought up by a fault, occur at the north-eastern corner of the range. These were seen from a distance only, but may represent those of series B.

CHIEF MOUNTAIN, FROM THE NORTH, ABOUT FOUR MILES DISTANT.

Chief Mountain, which projects still further to the eastward, is one of the most remarkable mountain masses of this region. It is nearly isolated from the rest, though surrounded by rugged foot-hills, which are covered with dense woods and wind-fall, rendering it very difficult of approach. As seen from the eastward, it resembles the base of a broken column, and from this point or from the north it may be recognized from a distance of over a hundred miles. On three sides, the central mass of the mountain is precipitous, and its bare rocky cliffs are of great height. To the west it appears to slope more gradually, and its summit is cleft by deep ravines. The perpendicular, central portion is composed of the limestones of series D, in a nearly horizontal attitude, but broken off abruptly on all sides along jointage planes. The rocks of the foot-hills are softer and no doubt belong to series C. In the Crow's Nest and other mountains to the north, similar forms, dependent on the same geological conditions, are reproduced. Chief Mountain

* Named Kaiser Peak on Captain Gregory's map referred to in a previous note, and stated to be 6,290 feet above the lake. In the height above given the revised elevation of the lake is added.

South Kootanie Pass.

Entrance to the pass.

The South Kootanie Pass has been from time immemorial one of the chief routes used by the Indians in crossing the mountains, and till a few years since was annually traversed by the Kootanies when on their way to hunt the buffalo on the eastern plains. Like most of the main valleys in the eastern part of the range, this is for some distance not thickly forested, and is characterized by wide grassy flats and open slopes. Country of this character extends from the eastern moutn of the valley to 'The Forks,' a distance of seven miles. There is scarcely any more striking view to be found in the mountains than that obtained from the hill over which the trail runs at the entrance of the pass, from which the eye follows the great trough-like valley for many miles to its termination at the base of the summit ridge. At the forks above referred to, two streams of nearly equal size unite to form that which flows into Waterton Lake, and is generally called the Kootanie Brook, though named the *Kin-nook-kleht-nan-na* on the map of the first Boundary Commission. Above the forks, both valleys may be described as generally wooded. The trail follows the southern branch, keeping on the northern side of the stream, passing along some rough hillsides and in one place winding between huge blocks, which have fallen from the neighbouring mountain. At about five miles from the forks, the trail begins the ascent of the summit ridge, and in a short distance emerges on bare, rocky slopes, which pack animals surmount with difficulty by a series of steep zig-zags. The watershed ridge has here an altitude of 7,100 feet, very nearly.* Both to the north and south of the point at which the trail crosses the summit ridge, its eastern face is extremely abrupt, consisting of rugged precipices of great height. Along its western side the descent is more gradual, and nearly follows the dip of the strata composing it. From the summit it may be observed that a number of the mountains both to the east and west of the watershed are much higher than the axial crest.

"The Forks."

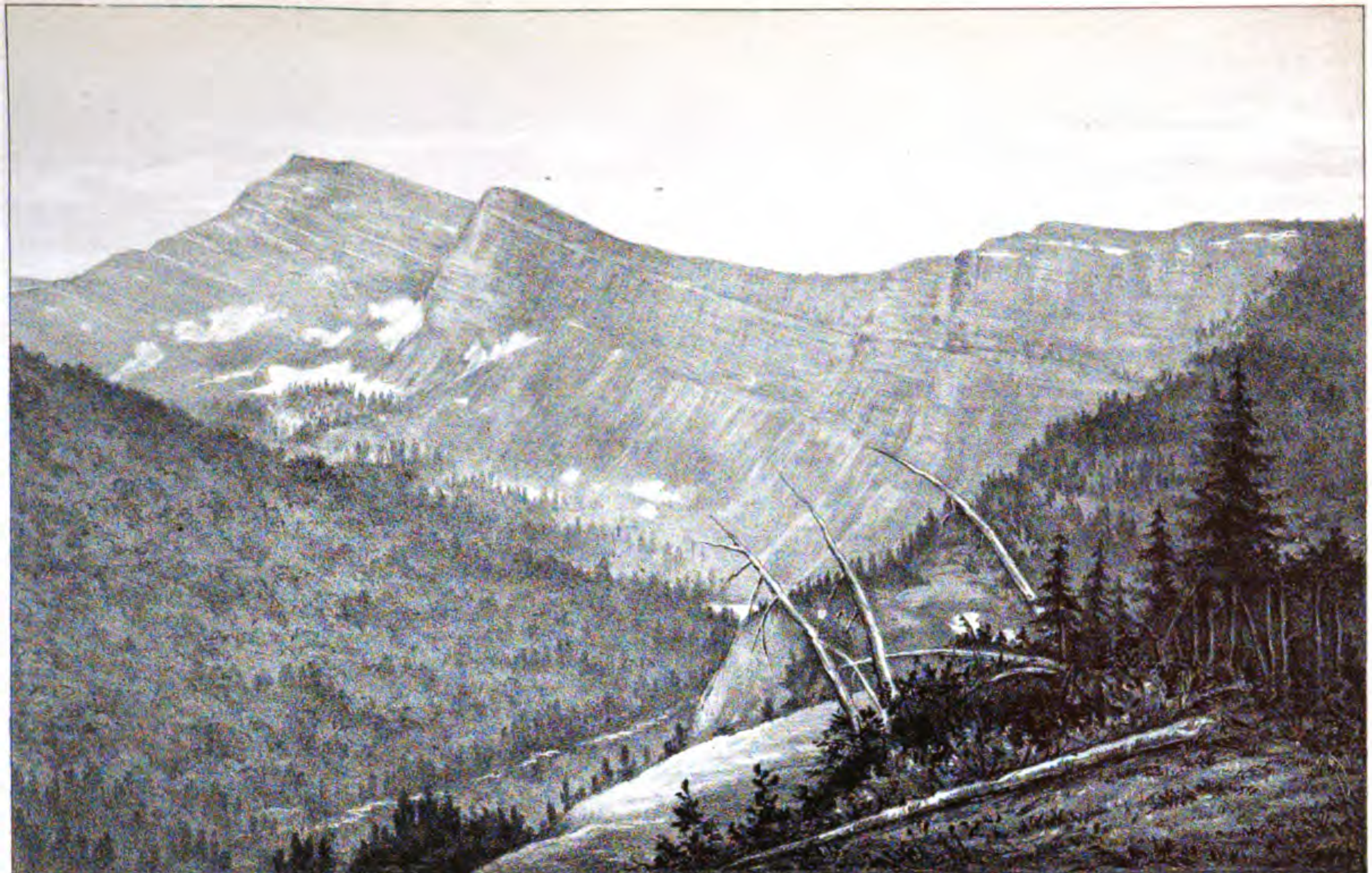
Summit.

Rocks of eastern part of pass.

The following description of the rocks met with in the eastern portion of the pass is taken with little alteration from my report of 1875, previously referred to. The edition of this report, published in connection with the Boundary Commission, having been limited, it is now completely out of print.

The rocks forming the mountains on both sides of the pass to the base of the watershed ridge have a general light westward dip, and

* In the Geology and Resources of the 49th Parallel its height is given as 6,673 feet; by Capt. Blackiston, from a single observation, 6,030 feet. The above is believed to be much more nearly correct than either of these. It is the mean of observations made in 1881 and 1883.



G. M. D., PHOTO., AUG. 10TH 81.

A. Mortimer, Lith. Ottawa.

LOOKING SOUTHWARD ALONG EAST SLOPE OF SUMMIT RIDGE, S. KOOTANIE PASS.

comprise the entire series in ascending order from C to F, both inclusive. An extensive fault, with north-west and south-east direction and downthrow to the north-east, evidently runs along the valley at the eastern base of the watershed ridge, and here breaks the continuity of the section.

The beds of Series C, are well displayed in the sides of the eastern part of the pass, and were there separated, for convenience of reference, into five sub-divisions. Subdivisions of series C.

The rocks at the entrance of the pass have a general south-westward dip. The lowest seen are in the bed of the brook, and must be well down in the series. They consist of very hard, greenish shales and compact, thin-bedded quartzites. In the mountain on the north side, they were seen to be overlaid by reddish, greenish and bluish-grey sandstones, with some shaly beds, all much hardened, but forming a talus and not well exposed. These were designated sub-division 1.

About midway up the same mountain, a massive bed of magnesian sandstone or grit appears, and constitutes sub-division 2. It must be about fifty feet in thickness, and great blocks which have broken from it are now strewn along the slope and encumber the pass. It evidently corresponds to one of the similar beds described as occurring on Waterton Lake, and lithologically also bears a close resemblance to that included in series B. It is composed of large, well rounded grains of transparent quartz, with occasional darker particles—the whole imbedded in an opaque, white calcareous and magnesian matrix, which turns brown on exposure to the weather. Magnesian grit.

Next in the series, and forming the summit of this mountain, is a considerable thickness of red, greenish and bluish-grey sandstones and shales, which, by their alternation, give the cliffs a curious banded appearance. They resemble those of the first sub-division, and may be named sub-division 3.

On the opposite mountain, on the south side of the pass, a series of bright red beds appear overlying the last. This constitutes sub-division 4, and is the same with that already noticed as occurring in Sheep Mountain and elsewhere in the Wilson Range. In following the trail westward, this zone is found to come down almost to the level of the brook, at about a mile and a quarter from the entrance of the pass. Its thickness at this place must be about two hundred feet, and from the exceedingly bright colour of the beds, it constitutes, wherever it occurs, an excellent reference horizon, and may often be detected even at a great distance. The beds composing this sub-division are hard, red, thin-bedded sandstones, with frequent thin intercalations of red argillaceous material, and one or two minor beds composed of pale greenish, shaly quartzite. A fifth sub-division, which intervenes in some places Red rocks.

between the red beds and the base of the limestones above, is not well seen in this part of the valley.

Series B. At about three miles from the entrance to the pass, in the bottom of the valley, and near the brook, are rocks, which though not closely examined, appear to belong to the limestone series B. These are probably continuously exposed in the valley which runs through to Cameron's Fall on the lake, being brought up along the axis of a low anticlinal.

The mountains about the head of the valley, which runs north-westward from the forks, afford fine sections and would merit careful examination in connection with the beds overlying the limestone series D, which are there well exposed. A very remarkable ridge-like mountain lies in the angle between the two streams, and, as seen from the main valley, has a sharp conical outline. This, on the map, I have named Anderson's Peak, in memory of the late Major S. Anderson, R.E., Chief Astronomer of the second Boundary Commission, and also a member of the first Boundary Commission expedition already referred to.

Anderson's Peak.

In following the valley of the southern stream, the trail, after crossing the northern branch, runs for about half a mile parallel with the axis of a gentle anticlinal, which has an east-and-west course, and passes eventually into the ridge-like mountain in the angle. In the bed of the brook, and well down among the variegated sandstones and quartzites of sub-divisions 1 or 3 of Series C, is an extensive exposure of coarse trap. It is not certain whether this is an interbedded mass or an intrusion. Over twenty feet in thickness is exposed. The rock is dark-colored and compact, and some large, loose fragments which appear to have been derived from the same bed, show remarkable stellar aggregations, several inches in diameter, of pale-green felspar crystals. Below the trap, and in the bed of the brook, an extensive series of banded red and green sandstones and quartzites appears. These beds all lie at low angles, and are not much disturbed, though somewhat corrugated on a small scale. A species of shaly conglomerate is here also not uncommon, though generally occurring in beds only a few inches in thickness. This rock is essentially a greenish, white or reddish quartzite, which encloses small, irregular fragments of green or red fine-grained shaly rock. The included shale-fragments resemble some beds found in the same series, and are probably the result of slight contemporaneous erosion. These peculiar conglomerates are not uncommon at several horizons in series C, and fragments of them have been recognized among the drift deposits far out on the plains.

Rocks near The Forks.

The upper part of the mountain already referred to as Anderson's Peak, which occupies the angle between the two streams, is com-

posed of the thick limestone beds of series D of the general section. These weather light brown or fawn-colour, and constitute the summits of the higher mountains on both sides of the pass. When, as in this instance, they form the crest of a peak or ridge, disintegration proceeding most rapidly along vertical lines of jointage, produces extremely picturesque and rugged outlines. When, however, merely exposed in the side of a mountain and still covered by other beds, they form steep terraced slopes or vertical cliffs of quite different aspect. The lower beds of the limestone in this vicinity are much more massive than the upper. Mount Blackiston, the towering mountain to the south, on the opposite side of the valley, probably includes the whole thickness of series D, with a small outlyer at the summit of series E, the contemporaneous trap.

Forms of limestone mountains.

At about three miles above the forks, the general westward inclination of the rocks brings the base of the limestones down to the bottom of the valley, while the contemporaneous trap, above referred to, appears at about the same place, capping the limestones in the mountains on the north side of the valley. The trap must here be at least fifty feet in thickness, and great masses have fallen from it into the valley below. The rock is greenish, purplish or brown in colour, and shows numerous amygdaloidal cavities. It is probably a diabase, though under the microscope it appears much decomposed. Series F and G also occur overlying the trap in the summit of the mountains in this vicinity, but were not here examined.

Bedded trap.

The rocks forming the watershed ridge, and seen on the trail from its eastern base to about three and a half miles beyond its summit, appear to belong entirely to series C. The fault previously referred to as probably running along the eastern base of the ridge was not actually observed, but the relations of the beds leave little doubt of its existence, and show also that a similar fault, but with a down-throw on the west side, must cross the valley of the trail, at the distance above stated, west of the summit—the summit ridge thus consisting of Cambrian rocks bounded by down-throw faults to the east and west. The steep ascent from the valley at the eastern base of the ridge is about 1,022 feet; on the west, a little brook is crossed at about three-quarters of a mile at an elevation 1,325 feet lower than the summit, or 300 feet below the stream last crossed on the east side. The rocks of series C, here met with, dip at low angles to the west or north-west. Red sandstones are abundant on the eastern slope, while greenish and grey schists and quartzites preponderate on the western.

Rocks of watershed ridge.

Near the point above defined as three-and a half miles from the summit, the valley of Akamina Brook joins that of the pass, from the southward. This valley was that followed both on the first and second

Akamina Valley.

Boundary Commission expeditions for the purpose of reaching the terminal monument marking the intersection of the 49th parallel with the watershed. The rocks observed in this valley and near the monument will be noticed before the description of the main section on the Kootanie Pass to the westward is continued.

Akamina Brook.

Rocks in neighbouring hills.

The valley of Akamina Brook runs up south-eastward almost directly toward the position of the terminal boundary monument on the watershed. The rocks exposed in the sides of the valley are chiefly red, or reddish sandstones, generally rather thin-bedded, but sometimes massive. They belong, for the most part, to the upper red series G. Series H, composed of flaggy, fawn-coloured beds, which are no doubt magnesian limestone or sandstone, form the soft-outlined and crumbling summits of some of the mountains on the south-west side. These rocks (the highest observed in this part of the mountains) were not closely examined. Though a greater or less thickness of them was frequently seen resting on series G, and differing from it markedly in colour, it was always at a great height above the valleys.

Camp Akamina

The spot known as Camp Akamina, the eastern terminal station of the old North-west Boundary Commission, is situated at the head of the valley just described. It has an elevation of about 6,000 feet above the sea, and is a sheltered hollow with thick spruce woods of fine growth. The Akamina Valley terminates just south of the 49th parallel in a fine, though small, cirque, holding a little tarn which is rimmed with shattered blocks of limestone. The terminal monument of the first Boundary Commission expedition stands in a saddle-shaped depression of the watershed ridge, walled in on two sides by high, rocky peaks, while the other two are bounded by an almost precipitous descent. Its altitude is 7,056 feet, according to observations of the first Boundary Commission. Far down, on the east side of the ridge, is a lake about a mile in length, from which flows the brook forming the Cameron Fall on Waterton Lake. In the opposite direction the view extends for eighteen miles down the valley of the Kintla Lakes, which are overhung by gigantic precipices and thickly-wooded slopes. Few landscapes to be met with in the mountains surpass those of this vicinity in grandeur.

Summit monument.

Rocks near summit monument. Series F. & G.

Near Camp Akamina the rocks are red sandstones, but are not well shown or regular in position. In the mountain side between the camp and the boundary monument, however, the rocks are well exposed, and here the character of series F and G of the general section was best seen, and over six hundred feet actually examined. The

section here embraces the lower beds of series G, and the whole of series F. The highest beds examined consist almost entirely of flaggy, dull-red, compact sandstones, which are frequently ripple-marked. Above these, about two hundred feet of similar reddish beds is visible in distant hill-sides, and these again are overlain by the upper fawn-coloured series H. In descending, from the beds first mentioned, the red begin to alternate with grey and fawn-coloured sandstones, the latter magnesian, and white on fresh fracture. Lower in the section, while red and purplish-red sandstones still continue, whitish and fawn-coloured limestones—frequently concretionary—are intercalated, and become thicker and more frequent toward the base. The lowest rock seen in series F, is a dark-purplish sandstone, and not far beneath it, is the trap designated in the general section by the letter E. Many of the sandy beds throughout the entire section are ripple-marked, and rain pitting and sun cracks are not infrequent. At several different levels, too, the surfaces of sandstone beds show impressions of salt crystals, which have subsequently been dissolved and replaced by clayey matter. Some of these are as much as half an inch in diameter, and exhibit distinctly the peculiar hopper-shaped forms characteristic of sodic chloride.

Ripple marks and impressions of salt crystals.

The division made between series F and G, and that between G and H, are probably not of great importance. No unconformity obtains, and very similar conditions of deposition appear to have prevailed throughout, the deposition of reddish sandstone alternating with that of pale dolomitic sandstone and magnesian limestone. The divisions are therefore recognized as a matter of convenience only, and are founded on the different colours of the zones as they appear in the mountain sides.

Relations of upper members of section.

The trap E is still important at this place, though not so thick as in some other localities. It is dark-purplish in colour, and full of irregular amygdaloidal cavities, which are lined with green chloritic matter and generally filled with white calcite. Here, as elsewhere, it overlies the great limestone series.

South Kootanie Pass (Continued).

Akamina Brook is, as already mentioned, a tributary of the main stream followed by the South Kootanie trail. This stream, is on the map of the first Boundary Commission named Kish-e-nehn Creek. My observations in connection with the Boundary Commission extended only a few miles below the mouth of Akamina Brook, from which place the main valley runs nearly due south-east for about twelve miles to its junction with the Flat-head River, the total descent in that distance being about 700 feet.

Kish-e-nehn Creek.

Character of valley.

Below the mouth of the Akamina, the valley passes between two imposing mountain masses, named Mount Yarrell, and Mount Kirby and Spence, probably by Capt. Blackiston. For about five miles it is bordered on both sides by high mountains, rugged and bare about the summits; but beyond that point, lower wooded hills appear, which gradually decrease in elevation, and at the same time retire to a somewhat greater distance, the valley becoming more open. For the first five miles the trail is pretty rough, and the valley is generally wooded or encumbered with burnt forest. Further down there are some meadows, with good pasturage, and near the Flat-head River, a very pretty little prairie. At about three miles from the Flat-head, the trail crosses the forty-ninth parallel, where the observing posts and camping place occupied by the first Boundary Commission, in 1861, are still noticeable.

Trees.

Pinus flexilis (?) was observed growing with *P. Murrayana* on the river flats as far down as the mouth of the Akamina. A short distance further down the valley, the white birch (*Betula papyrifera*) was first seen, together with small specimens of larch (*Larix occidentalis*). Large specimens of the latter tree become common several miles east of the Flat-head Valley.

Fault west of watershed.

The fault previously referred to as probably bounding to the west the rocks of series C, which compose the region about the summit of the pass, must cross the valley about four miles west of the watershed. At about four and a half miles, rocks evidently belonging to series C, are exposed, dipping N. 43° E. $<$ 45°, or nearly the reverse of that met with at the last exposures to the east referable to the same series. The rocks are flaggy, red sandstones, often beautifully ripple-marked. To the south-west they are followed by the fawn-colored, shaly dolomites of series F, and these again by the contemporaneous amygdaloid which must here be at least fifty feet thick. Following this in regular descending order is the great limestone series (D) of the general section. The outcrop of this limestone is about a mile wide where it crosses the valley, the dip at an average angle of about 45°, and the thickness here probably at least 4,000 feet. The upper part of the limestone, immediately below the trap, is shaly and dolomitic, like that overlying the trap bed, but becomes flaggy and thicker-bedded in descending, and passes into a peculiar dolomitic limestone, which has apparently been shattered and re-cemented by ordinary non-magnesian, grey-weathering limestone. It is probable, however, that this appearance is really due to a segregative action. This is followed by limestone which shows many broad, rounded, concretionary surfaces of an almost botryoidal aspect, and this again by an ordinary fine-grained crystalline limestone. No trace was here observed of crinoidal limestone or of fossils of any kind, and the whole limestone series appears to be more or less dolomitic in character.

Series F. & E.

Limestone series.

In Mount Yarrell, on the north-west side of the valley, the great limestone series is a prominent feature, and is overlain by series E, F and G. These all dip uniformly to the north-east, forming a comparatively gentle slope in that direction, while the south-west side of the mountain is scarped and steep. The trap (E) must be about 100 feet thick in Mount Yarrell. Mount Kirby and Spence, on the opposite side of the valley, with a height of 9,290 feet, has an analogous structure, its highest points being composed, however, of limestone, while the higher series appear only on its north-eastern flanks. All the south-western and lower summits of this great mountain mass, are composed of the Cambrian rocks, above referred to as series C. These also form the south-western base of Mount Yarrell, and their line of junction with the overlying limestones crosses the valley at a point about six miles from the watershed. Mount Yarrell and Mount Kirby and Spence.

The Cambrian rocks here underlie the limestone series without any well-marked unconformity, the first beds met with being greenish and grey quartzites, and hard quartzose and argillaceous shales. These are followed in descending order by a contemporaneous trap, which is amygdaloidal, and much resembles that which constitutes series E in the general section. The trap at this place was the first found in association with the Cambrian in this district, but similar contemporaneous flows were subsequently discovered in these rocks in a number of places. Below the trap is a thick series of sandstones and shaly beds with a conspicuous red colour, though including also beds of white quartzite and some greyish, hard shales. These beds have, in some places, almost a ribband appearance, and in one part of the base of Mount Kirby and Spence are corrugated by a series of small plications. The last rocks seen in place in this valley are nearly opposite the termination of the high mountains above referred to, and must be far down in the Cambrian. They are grey and blackish, fine-bedded sandstones and sandy argillites, highly calcareous; and though not unlike some of the beds of series A, seen on Waterton Lake, they do not, like these, weather to bright brown colours. Careful search was made in these beds for fossils, but without the least success. The minimum total thickness of the rocks underlying the great limestone series—all probably referable to the Cambrian—must be about 11,000 feet. The dip is throughout uniformly toward the north-east at angles seldom less than 30 degrees. Contemporaneous trap in Cambrian. Character and thickness of Cambrian.

The point at which the Kish-e-nehn enters the Flat-head is about three miles south of the International boundary. It was intended to follow the Flat-head Valley northward to its head, to connect with the traverse previously made by the North Kootanie Pass, but this proved to be so extremely difficult, owing to the dense character of the forest Flat-head Valley.

and the numerous tangled wind-falls occurring in it, that after spending two days in making a total distance of about ten miles, it was abandoned, and a return effected to the mouth of the Kish-e-nehn. A few days hard work would doubtless have enabled us to reach the northern pass, but the wide Flat-head Valley afforded few exposures, and the atmosphere, during this part of the season (1883), was so densely laden with smoke that the mountains bordering it were completely obscured and very little useful work was possible.

Vegetation. The valley, so far as examined, is floored by wide-spread, gravelly and sandy terraces, and for about two miles north of the boundary line is diversified by numerous little grassy prairies. Further north it is almost entirely wooded, the flats being characterized by cotton-wood and spruce, the terraces covered with a thick growth of *Pinus Murrayana*. A few very large and many small larches (*Larix occidentalis*) and some Douglas firs (*Pseudotsuga Douglasii*) also occur. Near the boundary line, thickets of *Artemisia tridentata* were observed, and this appears to be about the northern limit of a part of the valley having a relatively very dry climate. The river-bed is wide and stony, and the river swift, and often split up into numerous sloughs and side channels.

Tertiary rocks. Rounded fragments of Cretaceous rocks are abundant in the river-bed, but were not seen in place. Tertiary rocks, resembling those assigned to the Miocene in the central plateau region of British Columbia, were met with in one or two small exposures in the bed and banks of the river, but poorly displayed and much disturbed by slides. They consist, so far as seen, of hard pale clays and sandy clays. It is probable that they underlie a considerable part of the width of this great flat-bottomed valley, though their extension to the north and south is quite indeterminate.

Pass west of Flat-head. The wide, longitudinal depression occupied by the Flat-head River, separates the Rocky Mountains, in this portion of their length, into two parts. The elevation of the Flat-head, where it crosses the 49th parallel, is about 4,000 feet. The trail crosses it three miles south of this line, at a ford, which, though easy at low water, would be impracticable at high water. From this point the trail continues westward to the Kootanie River, near the 49th parallel, but a few miles south of it all the way. It first follows up the valley of the Yak-in-i-kak Creek, of the map of the first Boundary Commission, to a summit at an elevation of 5,280 feet above sea-level, at a distance from the Flat-head of thirteen miles. Thence it descends to the Kootanie by the Tobacco River, (named Ak-o-no-ho Creek on the Boundary Commission map, and sometimes locally known as Grave Creek) for twenty-three miles, the total fall to the Kootanie being about 2,800 feet.

On leaving the Flat-head, the trail runs for about two miles southward across wide gravelly terraces covered with *Pinus Murrayana*, to the bank of the Yak-in-i-kak, where it turns westward. Numerous little prairies occur in the valley of the stream, for about four miles, beyond which the mountains, which have gradually been approaching it and increasing in height, crowd closely upon it, and it becomes everywhere densely wooded. About a mile further on, the trail leaves the bottom of the valley, and climbing far above the stream, passes along a steep and wooded mountain-side on the right, the valley itself being here cañon-like and impracticable. This very narrow and rugged portion of the valley, continues for about two miles, when it becomes somewhat wider, and the trail, gradually ascending, follows it, for the most part through woods, though occasionally on rocky slopes, on to the summit. The mountains increase very gradually in elevation from the edge of the Flat-head Valley, and everywhere present rounded outlines, tree-clad to the summits. Just east of the watershed, is a pretty little alpine meadow, from which the trail ascends steeply for a few hundred feet to the actual summit, passing there through a remarkable, dry, rocky notch between the mountains. In descending the Tobacco River, the trail is in some places rough and the valley is wooded till the western edge of the wide Kootanie Valley is reached. The mountains are everywhere rounded in form—differing much in this respect from the rugged outlines of the range east of the Flat-head—and are generally wooded to the summits. Yak-in-i-kak Creek.

The character of the vegetation in this western range indicates a much more abundant rainfall than in the eastern. *Abies subalpina* becomes abundant and large in the valleys, and a few specimens of *Pinus monticola* are met with. The larch is seen occasionally in the valleys, both east and west of the summit, but this tree is not abundant or large, till the edge of the wide valley of the Kootanie is reached. About four miles west of the summit, the Cedar (*Thuya gigantea*) and bracken (*Pteris aquilina*, var. *lanuginosa*) appear simultaneously. *Pinus ponderosa* is first seen at the edge of the Kootanie Valley, where with the larch and Douglas fir, it forms open groves of fine growth. *Pachystima myrsinites*—everywhere in these mountains characteristic of a cool, damp climate—disappears nearly at the point at which *Pinus ponderosa* first occurs. *Xerophyllum Douglasii* is abundant along almost the entire length of this pass. The cross-sections of the mountains by the various passes included in the present report offer very similar features in regard to the distribution of trees and characteristic plants, though in this case complicated by the intrusion mid-way of the dry Flat-head Valley. Vegetation indicating abundant rain-fall.

Observations of Mr. Geo. Gibbs.

Mr. George Gibbs, in the geological notes included in his paper already mentioned* gives a description, in outline, of the geological features of the South Kootanie Pass, and refers to that part of the trail between the Kootanie and Flat-head with more than usual detail. His observations on the general appearance and lithological character of the rocks are quite correct. Mr. H. Bauerman, in his report published for the first time in the last annual report of the Geological Survey, also describes the rocks occurring in this pass, and it will here be necessary to give only the main facts indicating the stratigraphical relations of the beds as now understood.

Carboniferous outlier.

In ascending the Yak-in-i-kak, the first rock met with in place is about three miles due west of the Flat-head. It is a hard yellowish-grey calcareous sandstone, in some beds reddish, the bedding planes of which frequently show pitted surfaces, the pits being from a quarter of an inch to half an inch in diameter and probably representing the position of annelide burrows. It is nearly horizontal, and in continuing westward, was observed to pass in some places a little below or above the plane of the original exposures into highly calcareous sandstones. About a mile further on, grey crypto-crystalline limestone appears, in considerable exposures, and it is evident that this sandstone (which much resembles that observed at the summit of Sheep Mountain, p. 42 B) is closely associated with the limestone series. Where the limestone was first seen it is fossiliferous or at least composed of crinoidal and other organic fragments. Among specimens collected here, a *Spirifer*, a *Productus*, and a *Fenestella* have been recognised. The limestones, in very thick beds, are the rocks characterizing the cañon-like part of the valley previously described, and extend for at least two miles along the trail. These limestones are those referred to as a Carboniferous outlier by Mr. Bauerman, who states that they rest unconformably on the rocks next described to the west—an observation not repeated by the writer, but without doubt correct. At the end of Mr. Bauerman's report is given a list by Mr. Salter of fossils collected from this outlier. Meek records *Productus latissimus*, *Spirifer Keokuk*, and *Athyris subtilita* as obtained here by Gibbs.†

Cambrian rocks

Beyond the limestones, the hill-sides become covered with fragments of shales and sandstones resembling those of series C, of the eastern part of the pass, and doubtless referable to the Cambrian. About two miles further on, and four and a half from the summit, immediately to the west of the mouth of a large brook which enters the valley from the

* Journ. Am. Geog. Soc. Vol. IV. p. 382, which see also in connection with the eastern part of the pass.

† Bulletin U.S. Geol. and Geog. Survey Vol. II. p. 354, Meek gives the locality as Katlahwoke Creek. The name given by Gibbs to the stream is the same employed in this report.

north-west, these rocks are well shown. They consist of flaggy, red sandstones, and fine, grey and bluish, hard, quartzose argillites, which are marked in many places by sun-cracks and rippling, Some beds show many impressions of salt crystals, precisely like those described on a former page, though on a horizon so much lower. About a mile further on, rocks of the same series, consisting of interbedded red and bluish-grey quartzites, were observed dipping N. 15° E. < 10°, with rippled surfaces, indicating a flow in a direction of N. 33° E. Well-marked jointage-planes also traverse the beds at this place, with a course of about N. 60° E., or nearly parallel to that of the valley. At the summit, bluish-grey and greenish, close-grained quartzites, are largely developed, in association with red sandstones; the former exactly resembling the Cambrian rocks seen near Elk River bridge (p. 78 B) and probably representing the same horizon. Half a mile beyond the summit is a remarkable, broad zone of bright-red beds dipping about N. 60° W. < 40°. Beyond this point the rocks were actually observed in place near the trail at two points only, but the mountains bordering the valley are doubtless composed of the same series to where they disappear at the edge of the wide Kootanie Valley. The direction of dip appears to turn more to the west in descending the valley.

Red beds with sun-cracks and rippling.

The part of the Kootanie Valley here entered, which, between the edge of the mountains and the Kootanie River, is about eight miles in width, is generally called the Tobacco Plains. It is described on a subsequent page. A little rocky projection, about three miles west of the base of the mountains, on the trail, shows a hard, greenish, amygdaloidal diorite (?), with siliceous filling, dipping N. 30° E. < 50° This is doubtless one of the interbedded masses of the Cambrian. With this exception no rocks were observed in this part of the Tobacco Plains.

Kootanie Valley.

North Kootanie Pass.

The eastern end of the North Kootanie Pass is situated in latitude 49° 30′. The western may be stated to be at the mouth of the Wigwam River, in latitude 49° 14′ 30″, the distance from point to point, being fifty-one miles in a general bearing of N. 64° E. This pass resembles the South Kootanie Pass in the fact that on it two separate high summits must be crossed, between which lies the valley of the Flat-head. Here, however, the extreme northern end of the valley is traversed, and the region between the two summits is consequently of a considerably greater elevation than the southern. In one respect the North Kootanie Pass differs remarkably from all others in this part of the range. The South Branch of the Old Man River—its eastern approach—occupies the centre

General character of pass.

of a wide gap in the eastern range of the mountains, where the continuity of the edge of the Palæozoic rocks is interrupted for a distance of about fourteen miles. The eastern entrance of the pass is therefore not so well defined as in other cases, but from the point which may be so designated, the trail passes for about fifteen miles through a broken, though scarcely mountainous country, resembling that of the foot-hills, before it reaches the first outcrops of the older rocks which constitute the actual summit range and watershed between the Saskatchewan and Columbia systems.

Valley of the South Fork.

The point above designated as the eastern end of the pass is about three miles west of Garnett Brothers' ranch, where the wide flats, here based on a belt of soft, dark Cretaceous shales, end at the base of a line of bold, partly-wooded hills, where the trail crosses the steep valley of a small stream from the north. From this place, for about four miles westward, or up to the mouth of the Little South Fork, the valley is wide; and open prairie stretches of considerable size not only characterize the terraces and flats, but spread up over the bordering hills. Thence, for about nine miles, occasional smaller meadows occur, but the valley is more than half wooded, and trees also generally cover the adjacent slopes, the appearance of the whole being very attractive. Beyond the last of these meadows a densely wooded country is entered, and owing to fallen trees and transverse gorges, the trail is very rough, though with the expenditure of a little labour it might easily be made excellent. From the last meadow to the summit is a distance of about six miles, but as the trail reaches the higher part of the vally, the timber becomes more scattered and open in growth. The source of the stream is found in two little intercommunicating lakelets about half a mile from the actual summit. The upper limit of the growth of trees is here nearly reached, and the hill-sides become almost bare, and are strewn with broken fragments of rock from the higher peaks. To the north, the eastern face of the watershed range, presents a fine series of limestone cliffs and crags running toward the Crow Nest Lake. The actual summit is crossed about half a mile from the lakes above referred to, at an elevation of 6,750 feet. It is a narrow defile between high rocky peaks, the trail passing over rough slopes of angular debris, almost entirely destitute of vegetation.

Watershed summit.

Timber.

In the eastern portion of North Kootanie Pass, there is a considerable quantity of good timber. So far as the valley of the main stream is concerned, the best of the timber is included in a stretch of about five miles east of the summit. It is composed of Douglas fir, spruce, and black or bull pine.

Cretaceous basin.

The Cretaceous rocks met with between the entrance to the pass and the summit range, are all much disturbed and frequently sharply flexed

with probable overturning of folds to the eastward, and possible unproved faults. To work out their relations and present a complete section would require a very careful and detailed survey. The section appended to the general map (No. 5) shows a probable outline of the structure.

The rocks consist chiefly of sandstones of varying colour and texture, interbedded with shales, and in two places coal seams were observed, as described below. Some of the shales and shaly sandstones present a peculiar dark-greenish or bluish-grey colour. Conglomerates are not extensively developed, but in three places certainly, and probably in a fourth also, ash-beds and agglomerates, like those described in greater detail on the Crow Nest Pass, were found. It is probable that a closer examination would bring to light additional outcrops of these volcanic materials which appear to characterize a definite zone at the same stage with those on the Crow Nest Pass, and as they are wide-spread, they will ultimately prove of great value in forming a reference horizon in working out the complicated flexures of this part of the region. This volcanic intercalation has already proved useful in indicating the part of the section including the coal seams. The places at which these rocks have been recognized in the North Kootanie Pass are as follows:—1. About a mile west of the little brook at the entrance of the pass, in the bank of the main stream. The volcanic material is here considerably mixed with ordinary arenaceous matter and appears to be thinning out. 2. About six miles above the mouth of the Little South Fork in the banks of the stream, and forming part of a prominent hill on the south side. The only peculiar circumstance in connection with this outcrop is the occurrence of some obscure vegetable impressions, longitudinally striated. The carbonaceous matter has been removed and replaced by crystalline calcite. 3. About three miles east of the summit. Small exposures in a dense wood. There is probably a fourth outcrop between this point and the summit. In all these places the dip is westward at varying angles, and, indeed, the greater part of the entire Cretaceous series here exposed, dips in the same general direction, leading to the belief, as above stated, that a series of overturned folds exist. The entire thickness of the volcanic material was not shown at any of these points, but it is evidently much less considerable than on the Crow Nest Pass. The rock has a greenish-grey colour and is often distinctly fragmental, sometimes showing distinct fragments of amygdaloid an inch or more in diameter. It is generally speckled with greyish, greenish and reddish points, and is more or less calcareous throughout.

Volcanic rocks.

Places at which these outcrop.

Coal seams at entrance to pass

The first outcrop met with at the eastern end of this pass, in the steep banks of a small stream crossed by the trail, is important as showing coal seams, which are with little doubt referable to the same horizon as those in the Crow Nest Pass (p 69B). These are referred to on p. 99 c. Report of Progress 1882-84. The highest part of the section at this place consists of massive sandstones, twenty feet or more in thickness, below which is a coal seam two feet ten inches thick, and though somewhat variable, capable of yielding at least one foot six inches of good coal. This is followed by about thirty feet of shales and sandstones of general dark colours, below which is a second seam of coal one foot five inches thick. The dip is S. 45° W. $<$ 20. The coal, though thin, is of fair quality, and may prove to be of some value locally. The horizon of the seam is about 2,400 feet below the first exposure of the volcanic bed above noticed, and the series is apparently a regular ascending one between the two points. Some imperfect specimens of fossil plants were collected near the coal seam. Among these Sir J. W. Dawson has recognized *Podozamites lanceolatus* (Lindl.) and *Zamites montana* (Dn.)*

Second coal outcrop.

The second locality in which coal has been discovered in this part of the pass, is about four miles above the mouth of the Little South Fork, where the immediate banks of the stream become steep and the valley cañon-like. The exposures are on the south side of the stream and exhibit a considerable thickness of sandstones and shales, with coals and coaly layers or carbonaceous matter, at several stages. The beds are somewhat disturbed at this point, being bent into a small synclinal, and there is also a difference of appearance in different parts of individual layers, which may show that the great development of the coals at this place is a local phenomenon. No fossils were obtained, but the coals here are supposed to be at about the same horizon as those last noticed. The thickest seam shows nine feet nine inches of good coal, and is underlain by eight inches of shale, below which is a second seam fourteen inches in thickness, the whole being capable of yielding about ten feet of clean coal. Mr. Hoffmann's analysis of the coal of the nine-foot seam† shows it to contain.—

Hygroscopic water	1.93
Volatile combustible matter	23.23
Fixed carbon	57.50
Ash	17.34

Beds adjacent to coal.

The disturbance of the measures would render this an unfavourable point for the actual working of the coal, but the seam

* See Proceedings Royal Soc. of Canada, Vol. III., Sec. 4.

† Report M, p. 8.

might be traced up to some more suitable locality in the neighbouring hills. Some of the massive sandstones in this vicinity were observed to overlie the beds including the coal with apparent unconformity. This is the only place in which any appearance of unconformity has so far been met with, among the very thick Cretaceous series of the mountains, and it is probable that it may have resulted merely from local contemporaneous erosion and may here have no fundamental structural importance.

The entire section observed at this place, as measured by Mr. J. B. Tyrrell, is as follows, in descending order.— Section including coal.

	FEET.	INCHES.
1. Thick-bedded, yellowish-weathering sandstone	—	—
2. Thin-bedded sandstone	10	0
3. *Coal*	1	0
4. Sandy shale	8	0
5. Sandstone	8	0
6. Shale	0	3
7. *Coal*	9	9
8. Shale	0	8
9. *Coal*	1	2
10. Sandstone and shale	6	0
11. *Coal*	3	6
12. Sandstone and ironstone	3	0
13. *Coal*	3	5
14. Sandstone	2	0
15. Carbonaceous shale	6	0
16. Sandstone and sandy shale	30	0
17. Carbonaceous shale	2	0
18. Sandstone and ironstone	6	0
19. Coaly shale	8	0
20. Sandstone	25	0

Under this lies a bed of dark shale, then a bed of light shale, and then another bed of dark shale.

The rocks of the Cretaceous series are last seen about a mile and a half from the summit, where the older formations of the Flat-head Range appear. The junction of the two series was not seen, but it is almost certainly a faulted one, the Cretaceous being brought in by an extensive down-throw to the east. The older rocks dip nearly due west, at an average angle of about 30°, and it might be supposed that they form an overturned anticlinal, like those so frequently met with in this part of the mountains, but that this is not the case is shown by the fact that they occur in regular *ascending* order. The first of the older rocks seen is a grey, compact limestone, which is followed and overlain by a series of yellowish-grey, flaggy, more or less dolomitic limestones, at least 200 feet in thickness. These are followed by sandstones for the most part red, which show ripple-marks, sun-

Fault east of summit.

Rocks overlying limestone series.

cracks and pseudomorphous impressions of salt crystals. Over these lies a bed of contemporaneous trap, about 100 feet in thickness, which can be traced running up the slopes of the mountains on both sides of the valley, forming bold cliffs. This is followed, in ascending order, by a second series of red beds, reproducing the characters of the first, but about 600 feet in thickness, above which is a series of flaggy and shaly dolomitic sandstones, weathering to brown and fawn colour, and showing in some layers impressions of salt crystals. Drusy cavities were observed to occur in a few places, lined by small dolomite crystals, with a few of baryte and copper pyrites. The thickness of these rocks is again about 600 feet. They are followed by a similar volume of red beds, almost entirely sandstone, which frequently form rather thick layers. These continue to the actual watershed, and are the highest beds seen at the summit of the pass, where another extensive fault causes them to abut on the older limestones. Near the fault, these sandstones have become locally changed into hard quartzites of a purplish-grey colour, in which the iron appears to have become concentrated in certain layers while the intervening laminæ have become almost colorless.

Summit fault.

Comparison with Triassic rocks elsewhere

The rocks here displayed evidently represent those from the summit of the great limestone series, to the top of the section as represented in the South Kootanie Pass, or from series D, upward. They may be summarized as below to facilitate comparison with the section on page 59 B. It will be observed that while the general conditions of deposit indicated by the red and fawn-colored beds are similar in both sections, the thickness and arrangement is somewhat different in the two localities, the most important change being the existence here of a considerable thickness of red beds below the trappean flow. There is every reason to believe that the trap occurring above the great limestone series represents a single period of eruption, as its continuity is unbroken for many miles, where good sections enable it to be followed, near the South Kootanie Pass. This being so, it would appear that the conditions producing the red sandstones set in somewhat earlier to the north; and further, from its association, that the trappean eruption should be classed rather as a portion of the red series than as a separate member between this and the limestones.

General section

The entire section is as follows in descending order.—

		FEET.
1. Quartzites and red sandstones		610
2. Fawn-coloured beds	(about)	600
3. Red sandstones, shales, etc.	"	600
4. Amygdaloidal diorite (?)		100
4. Red sandstones, shales, etc		100
6. Yellowish, dolomitic, flaggy limestone, 200 or more		200
		2,210

Little South Fork.

Before continuing the description of the pass west of the main summit, a few words may be added respecting the Little South Fork. This stream, the most important tributary of the South Fork, joins it four miles from the entrance of the pass. The Little South Fork is nearly equal to the main stream in volume and is formed, at a distance of about six miles above its mouth, by the junction of two rapid streams, each about thirty feet wide by six inches deep, fed by a number of smaller brooks which issue from rugged valleys in the limestone mountains. A well-beaten Indian trail runs up the western branch, and probably passes over the range to the head-waters of the Flat-head, though it was followed about two miles only above the forks referred to. The valley of the Little South Fork is wide, with many patches of prairie, and some of the adjacent hill-slopes have been almost completely denuded of timber by fire. The Cretaceous rocks exposed along the stream are generally sandstones and present no features of special interest, though a band of dark shales and shaly sandstones, several hundred feet in thickness, occurs near the mouth. The strike is very regular in the lower part of the valley, averaging N. 50° W. with dips at an angle of about 30° south-westward. A specimen of *Pinna Lakesii* was found in sandstone on the west side of the stream, and with the exception of some fragments of Belemnites, is the only fossil mollusc obtained in the Cretaceous rocks of this vicinity. Character of valley. Rocks.

Gravel banks nearly one hundred feet high, occur in some places on the stream, and these, toward the base, are hardened by calcareous matter into a species of conglomerate. No overlap of the Cretaceous rocks on the older beds of the mountains was observed, but it is probable that the irregular edge of these rocks to the south is partly of this character and in part defined by faults. At this point the end is found of the important trough (Crow Nest trough) of Cretaceous rocks which runs northward behind the first range of the mountains for ninety-five miles.

North Kootanie Pass (Continued.)

From the east or main summit on the North Kootanie Pass, the trail descends rapidly to the south-west by the valley of a small brook, which in three miles joins the Flat-head. It then follows the north bank of the Flat-head, crossing four considerable and several smaller brooks, and in fourteen miles further reaches the source of the river and the western summit. The valley is generally wooded, but in its lower part several little meadows occur, and near the western summit the Head-waters of Flat-head.

woods become open in consequence of the altitude attained, and little alpine meadows are frequent. The ascent to the western summit is quite gradual, but on attaining the crest, it is found to be a narrow ridge, broken off very abruptly toward the south-west. The summit is partly open and remnants of snow drifts may be found in sheltered hollows throughout the summer. There is good pasturage for a few animals here in July and August.

The height of this summit, where crossed by the trail is 6,850 feet, but the ridge might be passed at a lower level further to the south-east. The lowest part of the trail between the western and eastern summits is quite near the latter, and has an altitude of 4,925 feet.

View from western summit. From the western summit, the whole basin which constitutes the head of the Flat-head Valley is well seen. The region between this and the eastern or watershed range, and northward toward the Crow Nest Pass and the Elk River, is occupied by rounded hills, which are arranged more or less definitely in linear series, forming ridges with general north and south trends. The slopes are not usually abrupt, and both the hills and intervening valleys are almost everywhere densely wooded and show but little burnt wood or wind-fall. There must be a very considerable quantity of good timber in this region, chiefly spruce. The summits of the hills are generally about equal in height, their average elevation being a little over 6,500 feet.

The view from the west summit, looking down the gorge of the Wigwam River, must be very fine, but was much obscured by smoke at the time of my visit. To the south and south-east is a mass of high and wild limestone peaks forming the northern part of the Macdonald Range.

Wigwam River. The descent from this summit to the head-waters of the Wigwam River is at first extremely steep and rocky, and the trail passes in the valley through dense woods for nearly four miles before the first little opening in which pasturage can be obtained is reached. Three miles further on, the main stream of the Wigwam enters the valley. It rises, according to the Boundary Commission maps, quite near to the western summit of the South Kootanie Pass, a few miles south of the 49th parallel. Opposite the mouth of the main river is a high mountain, crested toward the summit by limestone cliffs, and named North Bluff by Blackiston. West of this point the valley opens more widely, though the river still runs in a deep, narrow gorge in its centre. The trail here leaves the stream and passes for nearly three miles over a high stony terrace-flat, on which lie a number of large, detached, angular blocks. It then descends by several steep zig-zags to a lower terrace, which occupies the angle between the Wigwam and Elk rivers. Near the mouth of the

Wigwam, the Elk may probably be forded at low water, but the trail now generally followed runs up the Elk River, on the east side, for about three miles, to the bridge which has been thrown across at the upper end of the cañon. (See p. 78 B.) This part of the trail is rough, following a broken slope above the edge of the chasm, several hundred feet in depth and with almost vertical sides, in which the Elk here flows.

The valley of the Wigwam and adjacent hills and slopes are generally well wooded, particularly on the south side of the river, and as this pass has as yet scarcely been used, save by Indians, very little destruction from forest fires has occurred.

Rocks between east and west summits.

No detailed section can be given of the rocks between the east and west summits on the North Kootanie Pass, as the country is all densely wooded and exposures are few. The general structure is, however, sufficiently simple, being that of a synclinal of Cretaceous rocks, of which the east side dips westward, while the opposite side dips to the north-east. The rocky notch by which the trail crosses the eastern range is evidently a break produced by an extensive fault, with down-throw to the eastward. This has already been referred to (p. 60 B) as the summit fault, and by it the red sandstones and associated rocks of the mountains on the east side of the notch, and stream beyond it, are brought in contact with the massive Devono-Carboniferous limestones on the west. The throw of the fault must be at least 1,500 feet, and is probably much greater. It runs about N. 40° E. through the notch, but appears to turn to nearly due north on the east side of the summit. A number of fossils were collected from the limestones near the summit, among which a preliminary examination shows the following forms.—

Faults.

Dendropora.	*Strophodonta*, Sp.
Aulopora.	*Spirifera Maia.*
Syringopora (?).	*Atrypa reticularis.*
Striatopora.	*Atrypa spinosa* (?).
Zaphrentis.	*Retzia Verneuiliana.*
Productus Hallanus (?),	

There are probably several other important faults in this neighbourhood, one of which must run between the western base of the the summit range and the series of narrow ridges of Cretaceous rocks which lies south of the Flat-head, where it is first reached by the trail. This is rendered evident by the fact, that to the north of the river the Cretaceous sandstones rest directly on the limestones, while they are here brought in contact with the much higher red rocks, and though the Cretaceous and limestone series must be regarded as unconform-

able, it is improbable, from analogy with other parts of the district, that they lie upon two such different portions of the older series within so short a distance. The ridges last referred to run about north-east and south-west, and appear to form a system isolated by faults from those characterizing this basin generally.

Junction of Cretaceous and limestone series. At the summit notch, the limestones dip northward at rather low angles. They form the mountains on the north side of the trail and Flat-head River, to the second large brook which is crossed (a stream of about ten feet by six inches), dipping, where last seen, nearly west, and having a total width at right angles to the strike of about five miles. The gravel in the bed of the brook just referred to, is about half Cretaceous sandstone, the remainder being either limestone or pale calcareous sandstone of the kind subsequently mentioned as forming the upper layers of the limestone series on the Crow Nest Pass. It is probable that the Cretaceous here rests directly on the calcareous sandstones, as occurs a few miles northward at the upper Crow Nest Lake.

Cretaceous basin. The main Cretaceous synclinal above alluded to, from this point, where its eastern range is reached, to the crest of the western summit, is almost nine miles wide, on the line of the trail. It may be complicated by minor flexures. It is conjecturally terminated southward on the map, according to the observed general strikes of the rocks, though the region here lying between this and the South Kootanie Pass was not examined. The ascent to the western summit is made nearly on the slope of the beds which dip north-eastward at angles not exceeding twenty degrees, and consist, so far as seen, of sandstone of the usual character, with some conglomerate. These are well exposed along the crest and on the escarpment of the summit ridge on the Wigwam River side, where they dip in a similar direction at an angle of about forty degrees. A short distance down the escarpment, the sandstones become rather shaly and one or more thin coal seams occur. The Cretaceous series extends on the trail for about two miles beyond the summit and where last seen was nearly vertical. It would appear that the thickness of the Cretaceous series, from the rocks at the summit of the ridge downward is at least 7,000 feet, though the section is not continuous.

Limestone ranges near Wigwam. The rugged mountains already mentioned as lying to the south and south-east of the summit ridge, appear to be entirely or chiefly composed of limestone, the Cretaceous rocks of the summit ridge terminating among them in the form of a bay. The range to the south shows from a distance a sharp anticlinal fold as its dominant structure. The precise south-western edge of the Cretaceous was not defined on the Wigwam, the rocks being concealed for some distance north-east from the first range through which the valley cuts. This and a second range, beyond

it, are composed of limestone of the usual character. Between these mountain masses, on the north-west side of the stream, is a small area of greenish Cambrian quartzites. The lower hills about the mouth of the Wigwam are entirely composed of Cambrian rocks.

Cambrian rocks on the Elk.

About the mouth of the Wigwam, and for a mile and a half northward along the Elk, the Cambrian rocks are extremely disturbed and shattered, and from the number of jointage-planes cutting them in all directions, weather into steep, bare, rubbly banks, which are often nearly vertical. These assume pale tints where clayey matter has coated the joints, but in other places are bright-red from a coating of iron oxide. At the point last mentioned it is probable that a great fault or line of disturbance and comminution crosses the Elk very obliquely, with a course of about N. 10° W., as after passing that line, the massive Cambrian quartzites and slaty shales are found nearly undisturbed, with light undulating dips, weathering out in block-shaped masses only, and forming the vertical-sided cañon which is crossed by the bridge (p. 78 B).

Vegetation.

The character of the change found to occur in the vegetation, and particularly in the timber, in crossing from the eastern to the western side of the Rocky Mountain range, having previously been noted in connection with the South Kootanie Pass, need not be repeated here. It may, however, be mentioned that the Douglas fir occurs in the valley of the South Fork, on the east slope, and near the mouth of the Wigwam on the west side. It is never an alpine tree in this region. The trees found near both summits are chiefly *Abies subalpina*, *Picea Engelmanni* and *Pinus albicaulis*. The vegetation about both summits is, as might be expected from the altitude, quite alpine in character. The little meadows on the west summit, still partly covered by patches of snow, were gay with the bright yellow flowers of *Erythronium minor* on the 26th of July. On the east side of the eastern summit, a hill-side was observed a few days later completely covered with the beautiful *Rhododendron albiflorum*.

Crow Nest Pass.

General character of the pass.

This pass is that which has of late years been most used as a means of communication between the Great Plains and the Kootanie country. A practicable trail has been cut out, and bridges built over several of the larger streams, and considerable numbers of horses and cattle have been driven east by it. The trail, as now laid out, does not correspond with any well-known Indian route, and though possessing some advantages over the North Kootanie Pass, is by no means so direct. It follows up the Middle Fork of the Old Man, or Crow Nest River to its

source, beyond the Crow Nest Lake, crossing a low summit to the head-waters of a branch of Michel Creek, a tributary of the Elk. Another summit is crossed between Michel Creek and Coal Creek, also a tributary of the Elk. Coal Creek is then followed down to the Elk. After reaching the Elk, the trail runs along the east bank of the river to the cañon where a bridge has been thrown across. The wide Kootanie valley is finally entered at a point only a few miles north of the western end of the North Kootanie Pass.

Valley of the Middle Fork. The eastern end of this pass is well marked by the Livingstone or outer limestone ranges of the mountains, cut through by the Middle Fork in a deep, narrow valley. This is usually designated "The Gap." Within the Livingstone Range, the valley of the Middle Fork is wide and open as far as the lake, or for about eight miles. This part of the valley is characterized by wide, grassy terraces, and many of the hills bounding the valleys to the north are open and grassed to their very summits. Those on the south, are, however, generally wooded, and north of the valley, the whole country becomes either densely wooded or covered with burnt woods and wind-fall, after the first two or three miles. It was my intention in 1883 to strike northward from this part of the valley to the North Fork, but after losing an entire day in making a very few miles, and seriously injuring one of our horses, this was abandoned. The hills to the north and south of the valley are in reality the ends of series of nearly parallel ridges, presenting remarkable uniformity and conforming in direction with the strike of the rocks.

The valley of the Middle Fork, between the Livingstone Range and the lake, like all those in the eastern part of the mountains, where extensive meadows border the streams, is extremely attractive in appearance. The Crow's Nest Mountain, standing alone amid lower hills, three miles north of the trail, and the high limestone peaks which crowd upon the lake on both sides, present fine rugged outlines.

FIG. 2. THE CROW'S NEST. FROM A HIGH RIDGE, ABOUT THREE MILES EAST.

The height of the Crow's Nest was approximately determined as 7,830 feet above the sea, and though much less than that of other peaks in this part of the range, its nearly conical outline and isolated position, render it à prominent object as viewed from the plains far out to the south-east. On one of the maps accompanying Captain Palliser's preliminary report* it is named *Loge des Corbeaux*. Its Cree name, of which the others are translations, is *Kah-ka-ioo-wut-tshis-tun*. Viewed from the pass or neighbouring ridges, its summit is seen to be entirely composed of the great Devonio-Carboniferous limestone series in a nearly horizontal attitude. Its apex is bluntly conical and is bordered by almost vertical cliffs. To the north, a lower spur attaches to it, crested by several remarkable chimney-like columns of the same limestone. This mountain in its structure and general appearance much resembles Chief Mountain, previously described. The highest peak on the south side of the Crow Nest Lake has an altitude of 8,600 feet. Crow's Nest.

Geologically considered, the eastern part of the Crow Nest Pass affords a section of the great eastern Cretaceous trough† parallel to and about ten miles north of that of the North Kootanie Pass. The trough is here, however, about seven miles only in width, and its eastern margin is strictly defined by the limestone outcrop forming the Livingstone Range. The structure met with in this pass is represented in a generalized way on section No. 4. Probably as a consequence of the protection afforded by the massive limestone rocks of the Livingstone Range, the Cretaceous rocks of this part of the trough are much more regular and undisturbed than on the North Kootanie Pass. Just where the Middle Fork breaks through the Livingstone Range, the strike of the limestones and Cretaceous rocks changes from nearly north, on the north side of The Gap, to south-east on the south side. It is probable that this change is connected with a line of fracture or weakness which has been followed by the river, though there is no reason to believe that actual faulting occurs to any considerable extent. Crow Nest Cretaceous trough.

The precise character of the junction of the Cretaceous of the foot-hills with the limestone of the east base of the Livingstone Range at this place, is doubtful, the rocks being much disturbed, and varying within a short distance from vertical to nearly horizontal. Immediately north of The Gap, however, a mass of Cretaceous sandstones is seen on the flank of the limestone range, dipping at a low angle toward it, *i.e.* westward. The limestones also dip westward at varying angles, averaging Livingstone Range.

* Papers relative to the Exploration by Captain Palliser, etc., 1859.

† This Cretaceous area may be designated the Crow Nest trough, to distinguish it from others in the mountains. It was first observed by me in this pass in 1881. See Prelim. Note on Geology of Bow and Belly Rivers District, 1882.

about forty degrees, but in some places becoming nearly vertical. The impression at first conveyed is that the limestones are brought up by an extensive fault running along the base of the range parallel to its direction, but the proved existence in a number of places of overturned folds, and the resemblance of the limestone ridge here to an anticlinal of this character, leads to the belief that it is an overturned anticlinal, combined with a fault with down-throw to the eastward. On comparing the parallel portion of the North Kootanie section, it even appears probable that the first large overturned Cretaceous anticlinal on it may be the southern continuation of the same fold, which has here become so considerable as to bring the limestone to the surface.

Cretaceous, east of Livingstone Range.

Outside the Livingstone Range, the Cretaceous rocks met with on the trail eastward, to the wide, crumpled belt of dark shales which runs through from the South Fork (see map accompanying Report of Progress, 1882-84), are chiefly sandstones, generally greenish-grey in colour, and sometimes shaly. In some beds, the sandstones are brown-weathering, and in others, pale grey, weathering to reddish tints. These rocks all dip very regularly to the south-west, at angles of 30° and upward. The valley crosses them very obliquely, and no extensive beds of dark shales were observed. The sandstones are sometimes so hard that they might almost be described as quartzites. On the east side of a large brook which joins from the north, less than a mile from the edge of the limestone, rather massive beds of conglomerate occur, with westward dip at an angle of about 10°. The pebbles are all well rounded, and consist largely of chert from the limestones, together with quartzites and quartzose-schists like those of the Cambrian, among which a fine-grained, flesh-red quartzite is prominent. There are also some pebbles of a grey, slightly porphyritic crystalline rock, of which the origin is uncertain. On the west side of the brook, at a short distance, are thick beds of very hard, speckled sandstone, vertical, with a strike of S. 20° E.

The Gap.

In The Gap, the valley becomes quite narrow, but widens again immediately the limestones are passed. The breadth of the limestone axis on the trail, which crosses it nearly at right angles, is about a mile and a quarter. At its western edge, the rocks dip with great regularity westward, and are overlain by the Cretaceous sandstones dipping in the same direction and at a similar angle. Thence, for three miles, the only rocks seen were sandstones, which in one place were observed to become conglomeritic, and in another to be composed largely of whitish felspar in sub-angular grains. The section is not continuous, and could only be made so by including in an accurate survey the whole of the neighbouring hills; but the series appears to be a regular, ascending one, and if not complicated by unknown flexures

Rocks of Crow Nest Cretaceous trough.

Coal seams.

or faults, must be about 7,000 feet in thickness.* At this point the trail is crossed by a brook from the north, in which rolled fragments of coal were observed, and at a distance of about half a mile to the north, the seams from which these fragments had been derived were found in the banks. There are three seams in all, included in an exposed thickness of about forty feet of brownish, greenish and dark-grey shaly sandstones and shales, the whole being overlain by massive grey sandstones. The highest seam is two feet thick, and is separated by about twelve feet of shales and shaly sandstones from the next, which is two feet ten inches thick, and about fifteen feet below it is a third, one foot five inches thick. The dip is here S. 85° W. $<$ 30°. The coal is a bituminous one, and yields a firm coke. An analysis by Mr. Hoffmann shows it to contain only 1·82 per cent. of water, and 51·22 of fixed carbon. It yielded, however, 22·41 per cent. of ash. (see p. 6 M.)

The appearance of the section including these coals is so close to that previously noticed as occurring at the entrance to the North Kootanie Pass, that I believe the horizons represented to be identical.

Beds overlying the coals.

For a distance of a mile and a third from these exposures, grey sandstones, with occasional layers of cherty conglomerate and greenish-grey shaly sandstones, are exposed at intervals. It is very probable that there is a considerable proportion of shales, but if so, these, owing to their soft character, are for the most part concealed.

Volcanic rocks.

At this point the base of a great series of rocks of volcanic origin crosses the valley, and it was here, in 1881, that materials of this character were first observed in the Cretaceous of the region.† These rocks are chiefly, if not entirely, fragmental, consisting of agglomerates of varying coarseness, which are frequently so fine as to be designated volcanic ash rocks. They are for the most part greyish-green or purplish in colour, and toward the base, in some places, weather easily, forming rounded, crumbling masses. There are also reddish and grey, fine, shaly layers here and there, and small segregations of copper pyrites were seen forming scattered granules in some of the agglomerates. They are generally, if not in all cases, distinctly calcareous, effervescing freely on the application of an acid, and nepheline appears to be present in addition to felspar.

These rocks, owing to their greater homogeneity and resistance to weathering, form a high, straight strike-ridge, running for a number of miles to the north and south. Where they cross the stream, its immediate valley becomes narrow and steep sided.

* This is identical with the thickness—independently estimated—from the base of the formation to the horizon at which thin coal seams (probably the same with these) occur on the North Kootanie Pass. p. 64 B.

† It may be observed in this connection that Prof. J. J. Stephenson notes the occurrence of volcanic rocks and volcanic ash in the lower portion of the Cretaceous in Colorado. U. S. Geol. Surv. West of 100 Merid., 1875, Vol. III., p. 500.

Thickness of strata.

The thickness of the sedimentary beds intervening between the coal-bearing horizon and the volcanic rocks is here apparently considerably greater than where previously estimated at the entrance to the North Kootanie Pass, being about 3,350 feet. The thickness of the agglomerate and ash beds is about 2,200 feet, which is so much in excess of that elsewhere observed, as to lead to the belief that this place is not far remote from the centre of eruption which has produced this intercalation.

Probable faults

If the order of succession observed on the North-west Branch of the North Fork obtains here, a considerable thickness of shales should overlie the agglomerates. These, however, were not observed, and if present, must occupy a small breadth only. This fact, taken in connection with the circumstance, established on other grounds, that at the east base of Crow's Nest Mountain there is almost certainly a fault, with extensive down-throw to the east, which might be expected to cross the valley here, leads to the belief that the rocks met with west of the volcanic series, to the end of the lake, probably represent those underlying the coal horizon. So far as the exposures enable an opinion to be formed, the rocks are sandstones of similar character to those previously seen, with similar westward dips. The distance from the summit of the volcanic series to the last sandstone exposures at the lake, is three miles, and if regular and not disturbed by further faults, the thickness of the beds should be about 9,800 feet. The junction between these rocks and the limestone series, next met with, is evidently a faulted one.

Crow Nest Lake

The Crow Nest Lake, with an elevation of 4,250 feet above the sea, is about two miles in length, with an extreme width of a little more than half a mile. It lies in a deep, transverse valley which here cuts through the central limestone range of the mountains, and which enables the Middle Fork of the Old Man to draw a portion of its water from the country to the west of this range. The mountains rise in bold cliffs and scarps on both sides of the lake, rendering this, one of the most picturesque spots in the mountains, which is easy to reach. The old trail, turning to the north at the east or lower end of the lake, ran westward, nearly parallel to it, in a narrow, dry valley. A better track has lately, however, been found along the north shore of the lake itself.

Remarkable spring.

Half way up the lake, also on the north side, is a very remarkable spring which constitutes the chief feeder of the lake, and may be designated the source of the Middle Branch, or Crow Nest River. The spring issues from a large, overhung grotto in the face of the limestone cliff, the water welling up from the interior of the grotto, and filling a deep, clear pool at its mouth. It then falls about twenty feet to form a large, rapid brook, which, after a course of a few yards, loses itself in the

lake. The water has worked its way through the limestone along a nearly horizontal crack or jointage-plane, and is probably supplied by the drainage of the valley to the north of the mountains already referred to.

The immediate border of the lake is low at the west end, but a steep hill rises at no great distance back. At the base of this the valley bifurcates, the south-western branch conveying a stream of some size to the lake, the western, occupied by sloughs and woods, is followed by the trail, which, in a little over a quarter of a mile, reaches the narrow extremity of a second lake, which is between three-quarters of a mile and a mile in length. No water was observed to flow between the lakes, but it is evident that that last-described empties into the Crow Nest Lake at seasons of flood. Running northward from the upper lake is a flat-bottomed valley, in which, though not connected with the lake, a small stream rises, and flowing to the north and then north-westward doubtless eventually joins Michel Creek. The actual watershed between the Old Man and Elk River systems may therefore be said to be at the level of the upper lake, or 4,400 feet. The trail, however, at the west end of the upper lake, turns southward, following a small stream which enters the lake, then south-westward, crossing several rills which flow toward the stream previously described as falling into Crow Nest Lake, and eventually crosses the watershed at a point three and a half miles south-west of the upper lake, at an elevation of 4,830 feet. The actual height of land is therefore lower on this pass than on any other known south of the Yellow Head Pass.

Upper Lake.

Watershed region.

Rocks of the limestone series extend from the lower end of Crow Nest Lake to the west end of the upper lake, with a width of three and a half miles. The limestones constitute an almost uninterrupted section along the north side of Crow Nest Lake, and were ascertained to have an apparent thickness of 9,610 feet, with regular dip at an angle of about 30 degrees between S.W. and W. There is no appearance of any repetition by faulting in this section, and while the structure of the mountains elsewhere would suggest the probable existence of compressed and overturned folds, no distinct evidence of such folding could be found here. Compared with the thickness of limestone elsewere developed in the mountain region, however, that in this section is so great, that the thickness here may probably be actually due to repetition by folding, as indicated hypothetically on one of the sections attached to the map. The entire section, from west to east, in descending order, is as follows:—

Limestones on Crow Nest Lake.

		FEET.
1.	Cherty crinoidal limestone	1,680
2.	Compact, slightly crinoidal limestone	1,480
3.	White, crinoidal limestone	1,710
4.	Brownish-weathering, cherty limestone	1,040
5.	Massive grey limestone	1,220
6.	Grey and blackish limestone	460
7.	Fine-grained, grey limestone	1,420
8.	Cherty grey limestone	600
		9,610

Probable constitution of rock series. On the basis of the hypothetical folding indicated on the general section (*i.e.*, two compressed and overturned anticlinals, with an intervening synclinal) the actual rock-series exposed here would be as follows.—

		FEET.
1.	Calcareous sandstones (described below), at least	300
2.	Cherty crinoidal limestone	1,680
3.	More compact and less crinoidal limestones	1,595
		3,575

Fossils. Fossils, which were obtained at several different points on the line of the measured section, favor the view of a repetition of the beds, as they offered no distinct evidence of such a change in horizon as might be expected to occur between different parts of so great a thickness of strata. The principal fossils represented, most of which are characteristic Devonian forms, are included in the following list.—

Stromatopora, sp.
Crinoidal fragments.
Polypora stragula ?
Syringopora, allied to *S. perelegans*.
Diphyphyllum, sp.
Zaphrentis, sp.
Chonetes mucronata.
Productus sp.
Orthis, like *O. Tulliensis.*
Rhynchonella castanea.
Atrypa reticularis.
Spirifera, sp.
Cyrtina Davidsoni.
Platyceras (two or more species).
Euomphalus, sp.

Overlying No. 1 of the first section, on the west side of the valley, at the upper lake, are hard, whitish, more or less calcareous sandstones, which in some layers show cherty concretions, and are evidently a conformable upper portion of the Palæozoic limestone series. Similar sandstones were seen in the same position in many other parts of the mountains, and in some places have yielded Carboniferous fossils. These sandstones also constitute the ridge on the west side of the valley at the head of the upper lake, but in the next ridge, separated from this by a narrow valley only, sandstones outcrop, which evidently belong to the Cretaceous series, the line of junction of the two formations following the narrow valley between these ridges. Thence to the summit crossed by the trail, though at a considerable elevation and in the heart of the mountains, the country is characterized by low, broken hills and ridges, composed of or deeply covered by drift material resembling boulder-clay, and cut up by little ravines. Terraces are distinctly traceable to levels about 500 feet above that of the summit, and some of the ridges are evidently morainic in origin. This peculiar tract is shut in on all sides but the north-west by high and rugged mountains. It is thickly strewn with angular *débris* of Cretaceous sandstones, and its occurrence doubtless depends on the softer character of the rocks of that series. To the southward are two valleys. One, which holds a small tributary of the stream flowing to Crow Nest Lake, ends in a rather extensive snow-field; the other, further to the west, and wide, though not low, probably leads along the western foot of the main limestone range to the Flat-head Valley. The woods have been almost entirely removed by fire from the broken country about the summit.

Calcareous sandstones.

Base of Cretaceous series.

Broken, drift-covered country.

On descending from the summit, westward, by a rather narrow valley, the country becomes distinctly more humid in character, and the trail passes for several miles through fine woods. A mile and three quarters from the summit, it reaches the bank of the East Branch of Michel Creek, a large, rapid stream issuing from a wide valley running off to the south-east. This is followed for about a mile, when it is crossed by a ford. The track then runs over a wooded point and along some terraces, till, in three quarters of a mile, it reaches the east side of the West Branch of Michel Creek, a stream forty feet wide by ten inches deep. This is crossed by a bridge, and the steep hill-side forming the left bank of this stream is followed by a rough, difficult trail, till a descent is again made to the water-level at the mouth of Marten Brook, which joins from the north.

Descent to the westward.

From the summit to this point, the surrounding country is a mass of low, steep-sided, Cretaceous mountains, which seldom rise 2,000 feet, and often only 1,000 feet above the level of the stream. The

Cretaceous hills

valleys, which intersect them in all directions, are narrow and rugged. These hills, and those further west, to the Elk River, are an extension of the Cretaceous area which is overlooked from the western summit of the North Kootanie Pass (p. 62 B). The hill-sides are thickly covered with reddish boulder-clay, which is packed with stones of proximately local origin, and does not include limestone fragments. The same material forms terraces in lower places along the valleys, but at no very great elevation above the streams. With the exception of very restricted patches of living wood in the valleys or on remote slopes, the surface bristles with standing dead trees or is covered with fallen burnt logs.

Western summit and Coal Creek. Crossing Marten Brook, which is a small stream in a narrow rocky valley, the trail ascends rapidly, following a little stream from the level of the brook (4,800 feet) to that of the western summit on the Crow Nest Pass, with an elevation of 5,500 feet. In less than two miles a descent is then made by the valley of Coal Creek, of more than 1,100 feet, after which the stream has a less rapid descent, and in eight miles falls into Elk River, which at this point has an elevation of 2,200 feet.

The second or western summit on this pass, though actually higher than the main watershed, only separates the head waters of Michel and Coal creeks, both tributaries of the Elk. The trail crosses to avoid the necessary detour and thick timber which would be met with in following Michel Creek north-westward from the point where it is first reached, to the Elk. In taking this direct route, the trail reaches at the summit a height only a few hundred feet inferior to that of the surrounding Cretaceous hills. The appearance of the whole country from Marten Brook to the Elk, and in the wide valley of the latter, is desolate in the extreme, the forests with which it has been covered having been almost entirely destroyed by repeated fires, which have swept over the region since the Crow Nest Pass has become a travelled route. The valley of Coal Creek is deeply cut among the Cretaceous hills of monotonous and plateau-like outline, and no wide view of the country is obtained till the Elk is reached.

Calcareous sandstones. The geological features of this part of the pass are sufficiently simple. Near the point at which the East Branch of the Michel Creek is first reached, Cretaceous sandstones occur, but are immediately followed by whitish calcareous sandstones, underlying the last and representing those before described as attaching to the limestone series. These occur on both sides of the stream where it is crossed, and dip eastward at an angle of 35°. The calcareous sandstones probably occupy a small area only, as they were not again seen, and the fragments generally strewing the surface are so uniformly of the brownish Cretaceous sandstones and conglomerates as to indicate, even in the absence of expos-

ures, that these characterize almost the entire region. As, for three miles further, no exposures were met with in the valley of the West Branch of Michel Creek, it is uncertain whether these calcareous sandstones are cut off by a fault to the west, or form the salient angle of a fold.

Coal seams on Marten Brook.

Before reaching Marten Brook a low anticlinal of Cretaceous rocks similar to those above alluded to, is crossed, and on Marten Brook the strata have a westward dip at angles of 25 to 30 degrees. Marten Brook nearly follows the strike, and is interesting on account of the occurrence of coal on it. In a section at the trail-crossing, on the west side, is a seam showing a thickness of at least three and possibly four feet of very fair coal, with one stony parting of about two inches. Just above the crossing-place three thin seams are seen, one with nearly two feet of coal, the others less than a foot in thickness, and all irregular. A specimen from this seam, examined by Mr. Hoffmann, was found to yield a firm coke. It contained 2·12 per cent. of water, 43·48 per cent. of fixed carbon, and 27·48 of ash. The great proportion of ash being, however, partly due to adherent earthy matter in jointage-planes. (See p. 9 M.) A mile above the crossing are four seams, included in about a hundred feet of measures, all less than a foot in thickness, and similarly irregular. The beds associated with the coals are massive or shaly sandstones which often weather to yellowish or reddish tints, with grey and blackish shales and cherty conglomerates. A number of well-preserved fossil plants, characteristic of the Kootanie group, were collected here, including the following species.—*

Fossil plants.

Dicksonia, Sp.
Asplenium Martinianum, Dn.
Dionites borealis, Dn.
Podozamites lanceolatus, Lindl.
Zamites montana, Dn.
Zamites acutipennis, Heer.
Sphenozamites, sp.
Salisburia Siberica, Heer.
Salisburia lepida, Heer.
Baiera longifolia, Heer.
Pinus Suskwaensis, Dn.

Beds overlying coals.

Between Marten Brook and the west summit, the dips continue westward at angles of 20 to 25 degrees, and fully 1,500 feet in thickness of beds must here overlie the coals. The rocks, so far as exposed, con-

* Trans. Royal Soc. Canada, Vol. III., Sec. IV., p. 8.

sist of sandstones and conglomerates of the usual character. At the summit some very massive conglomerates were observed. On descending westward, the beds dip nearly at the angle of the slope, but afterwards turn northward, the strike then nearly coinciding with the direction of the valley, and the outcrops of the sandstone beds showing in the adjacent hills as horizontal or gently undulating lines. Five and

Coal Creek.

a half miles west of Marten Brook, on Coal Creek, coal seams of a few inches in thickness occur, associated with beds precisely like those of

Fossil plants.

Marten Brook, and holding fossil plants of the same species, among which the following forms have been recognized.—

Asplenium Dicksonianum, Heer.
Podozamites lanceolatus, Lindl.
Salisburia lepida, Dn.
Pinus Suskwaensis, Dn.
Sequoia Smittiana, Heer.

Coal-bearing horizon.

The horizon is probably identical, and the general effect of the section as shown on the trail, from Marten Brook to this point, is that of a wide, low synclinal. There is also every reason to believe that the coal-bearing horizon here met with, is the same with that described east of the Crow Nest Lake, and though the exposures are few near the main or watershed summit, it is not improbable that the same horizon may recur there, occupying the trough of a synclinal midway between the upper lake and the crossing of the East Branch of Michel Creek.

Near the mouth of Coal Creek, high eastward dips were observed, but these appear to be local, as the general aspect of the outcrops in the higher hills is nearly horizontal, with a slight though distinct tendency to dip away eastward from the valley of the Elk. In this part of the Elk Valley small exposures of soft crumbling sandstones were seen, but the valley is generally floored by terraced drift deposits.

Elk River.

At this point, the Elk is a swift, clear, blue, mountain river, about 300 feet wide. Its valley has not been examined, northward, for a distance of twenty-eight miles, but the gravel forming its bed here consists of Cretaceous sandstones and conglomerates, with much limestone, and there is no reason to believe that any rocks underlying the limestones come to the surface along this part of its course. Nearly opposite the mouth of Coal Creek, a stream which is evidently of considerable size and is known as Lizard Creek, joins the Elk from the opposite side. The valley of this stream is wide and straight, and is bordered by high mountains, particularly on the south side. From the high terrace on the east side of the Elk, it can be seen for about six

miles, running nearly due west, in which direction it appears to terminate among high, densely-wooded mountains. It would afford a direct route for the continuation of the Crow Nest Pass trail to the mouth of Bull River, on the Kootanie, and avoid the present detour to the south; but apart from the probably rough character of the intervening mountains, it is rendered impracticable by the impossibility of fording the Elk except at very low stages of the water. **Lizard Creek.**

This part of the Elk Valley runs nearly north-and-south in the heart of the Rocky Mountains. Following along the left or east bank of the river, the trail turns southward, and continues in that direction for eleven miles. The valley is from a mile to a mile and a half wide between the bases of the hills, and is occupied by terraces which are sandy and much cut up by denudation. The whole region, with the exception of some sheltered valleys along the west side, has been burnt over. The mountains on the east side rise about 2,000 feet above the river, with uniform outlines, and are all composed of Cretaceous rocks. Rocks of the same series are seen in the valley in a few places, and the depression appears to follow the strike of a belt of soft, shaly beds and sandstones, which must be low down in the Cretaceous. On the west side, the mountains are higher and more rugged in outline, and constitute the continuation of those mentioned as occurring to the south of Lizard Creek. These may be called the Lizard Mountains, for convenience of description. They are evidently composed of rocks of the Palæozoic series, which dip south-westward at an average angle of about 40 degrees, producing a steep escarpment-like front to the east. **Elk Valley.**

The river next flows south-westward for three miles, and then west for a like distance, in this part of its course cutting across the range just described. The valley is here narrow and bordered by high mountains, and is generally referred to as 'The Cañon,' though no really vertical rocky cliffs rise from the river, and at the lower end the mountains recede gradually, leaving rather wide flats, which are covered with fine timber, still unburnt, including much cedar. The rocks of the range cut through by the river are chiefly limestones, those seen near the trail resembling those of the lower part of the section on Crow Nest Lake; but higher up the slopes, much crinoidal limestone, like that of the upper part of the Crow Nest Lake section, must occur, as the *débris* in rock-slides is largely of this character. Specimens of fossils, including a small *Productus*, which resembles *P. Hallanus*, were collected here. This would indicate a Carboniferous age for the limestones. On the west side of the range, rocks of the Cambrian series, coming out beneath the limestones, owing to the easterly dip, form all the lower hills. **"The Canyon."**

On reaching the west side of the range, the river turns abruptly to the south, reaching the Elk River bridge a mile and a half lower down. After nine and a half miles of a south-westerly course, the Elk flows into the Kootanie River. The Crow Nest Pass may be said to terminate at the bridge, where the description of the North Kootanie Pass, given on a former page, also ends.

Cambrian rocks at the bridge.

The Cambrian rocks above alluded to are well exposed on some high hill-sides, followed by the trail near the west end of the narrowed portion of the valley; also in the banks and hills overlooking the river from a short distance above to several miles below the bridge. The most characteristic rocks are here greenish and greenish-grey quartzites, often of a very fine grain and regularly bedded. In these some layers are calcareous, weathering to a brown colour, the calcareous material being finely interlaminated with the siliceous, and in many cases forming remarkably twisted layers. These are evidently rocks of the same character as those described as "elephant's tooth limestones" in Mr. Bauerman's report, previously referred to.*

Elk River bridge beds.

Some of the calcareous layers hold numerous small, spherical, siliceous concretions of an oolitic character. Quartzose argillites are also present, and some beds of red ripple-marked sandstones. The attitude of the Cambrian strata is here not far from horizontal, and the massive greenish quartzites are supposed to occupy a position far down in the great Cambrian series of the mountains. For convenience of reference they may be provisionally designated the Elk River bridge beds.

Canyon.

The bridge is thrown across between two rocky cliffs, at a height of about fifty feet above the stream, which here begins its plunge over a series of small falls and through wild rapids into the deep and narrow gorge—a true cañon on a small scale—which it occupies from the bridge to the mouth of the Wigwam. This cañon is due to the fact that the massive quartzites are regularly jointed at right angles to their bedding planes, enabling the stream to quarry them away block by block and leave wall-sided cliffs.

Vegetation and timber.

The change in character in the vegetation met with in crossing from the east to the west side of the Rocky Mountain Range has already several times been adverted to, and is of the same general character in all the passes, being that from a dry region to one of very considerable precipitation. It is nevertheless of interest to note the point at which some of the more characteristic forms appear in each instance. On the west slope of the eastern or watershed summit, the woods, already described as of fine growth, consist of *Picea Engelmanni*, *Pinus Murrayana*, *Pseudotsuga Douglasii*, and *Abies subalpina*. *Pachystima myrsin-*

* See Report of Progress, 1882-84, p. 30 B.

ites was seen for the first time near Marten Brook. The cedar (*Thuya*) was first observed near the head of Coal Creek, and is abundant along the route followed thence, westward. *Sphæralcia rivularis*, *Spiræa betulifolia*, *Pteris acquilina*, var. *lanuginosa*, and in the same vicinity white birch (*Betula papyrifera*), were noticed in undergrowth on Coal Creek. Larch (*Larix occidentalis*) first appears about two miles from the mouth of the same stream. *Fatsia horrida*, not abundant in any part of the Rocky Mountain Range, properly so called, is established in a few places near the narrow portion of the Elk Valley. On emerging on the wide valley of the Kootanie, we pass at once from a humid mountain climate to a dry, lightly-timbered plain, which is often quite park-like, with an open growth of *Pinus ponderosa*, *Pseudotsuga Douglasii*, and *Larix occidentalis*, the last-mentioned appearing as tall, narrow, scanty foliaged trees, in many cases one hundred and fifty feet in height and three feet through at the base. *Purshia tridentata* is here common, and *Balsamorhiza sagittata*, last seen in the eastern foothills, reappears.

Head-waters of the North Fork of the Old Man River, and North Fork Pass.

Like the Middle Fork of the Old Man, the North Fork breaks through the outer or Livingstone Range as a large stream, carrying the waters of an extensive tract of Cretaceous hills which forms the continuation of the Crow Nest Cretaceous trough, and intervenes between the Livingstone and High Rock ranges. Unlike the Middle Fork, however, the North Fork derives none of its waters from the western side of the High Rock Range, this range here constituting the actual watershed. Drainage area.

In 1881 our surveys were carried as far as the outer edge of the Palæozoic rocks of the Livingstone Range, but as it was late in the autumn, and heavy snow-storms, with every appearance of winter had set in, I was unable to penetrate this range for the purpose of ascertaining whether the Crow Nest trough, which had been discovered a few days previously, extended so far to the north. In 1883 a special trip was made for this purpose, but having been unable to learn anything of the character of the country within this part of the Livingstone Range, we were not prepared for so great an extent of Mesozoic rocks as actually exists, nor to find so many and such long tributaries; so, after examining the South-west, North and North-west Branches to their sources, and exhausting our whole stock of provisions, we were obliged to return. In 1884, the head of the West Branch was reached by the North Fork Pass, from the Surveys.

Elk River, and a survey carried through from the North-west Branch to the southern sources of the Highwood River, thus completing the examination of all the main tributaries of the Old Man River.

North Fork Gap

The Livingstone Range,* where cut through by the North Fork, is quite narrow and abrupt, and though probably nowhere much surpassing 7,000 feet above the sea-level, is, owing to its rocky character, almost destitute of trees. 'The Gap' of the North Fork, as it is locally named, is a narrow rugged gorge crossing the range with a double curve somewhat in the shape of the letter S, and about a mile and a half in length. The river is very rapid in this part of its course, but shows no abrupt fall, and though the track at present existing through The Gap is rough, it would not be impossible, with a small expenditure, to make a practicable cart road to the open country beyond. The trail follows the south side of the stream, at first at a considerable elevation above it, but toward the west end, coming down to its level. Near the eastern end are three cairns; the first, a wide mound, about eight feet high, composed of stones and small boulders, and evidently very old, the two others smaller. As these are of no use as landmarks, they have probably been formed in the course of years by the addition of a stone by each Indian entering the mountains by this route, 'for luck.' On a narrow piece of flat open ground, a short distance further on, are the obscure remains of a couple of rectangles formed of larger stones. This place is well known to all the Indians, and named by them the "Old Man's playing ground." It is from this spot that the Old Man River derives its name, many superstitions attaching to the neighborhood. The 'Old Man,' Wī-suk-ī-tshak of the Crees, is a mythical character, with supernatural attributes, familiar under one name or other, to all students of American folk-lore.†

Indian cairns.

Livingstone Range.

The Livingstone Range here appears to have the structure of a compressed anticlinal, slightly overturned eastward and with a sharp synclinal pucker near the top, in consequence of which a few beds of flaggy dolomite, of an arenaceous character like those often found near the summit of the limestone series, are folded in at the crest of the range. The same beds are found dipping westward at the west end of the gorge. The mountains seem to be entirely composed of limestone, which in most places resembles the cherty upper portion of the series, as seen on Crow Nest Lake.

* In a map compiled by J. Arrowsmith (1862). The part of the Livingstone Range of Blackiston, between the North Fork and Highwood River, is named Comagh Mountains. See, British Columbia and Vancouver Island, by D. G. F. Macdonald, London, 1862.

† The name of the Old Man River in Cree is *Is-e-enoo-met-cwe-win-si-pi;* in Stoney, *Is-sa-goo-win-ih-ska-da-wap-ta.* It will be sufficiently obvious why these names have not passed into common use.

The Livingstone Range once passed, a country of lower rounded hills is entered, which resembles in all essential respects the rougher portions of the eastern foot-hills. The lower parts of the valleys which converge in it towards The Gap, are wide, and show long stretches of meadow and prairie, the total area of which, including that of open hill-sides, cannot be less than 19,000 acres. There is reason to believe that the snow-fall here is less than in the higher foot-hills, and a considerable number of cattle or horses would find abundant pasture.* Valleys west of range.

Just within The Gap, the valley of the North Fork bifurcates, the main hollow running north along the inner side of the Livingstone Range, the second, occupied by a stream which may, from the general trend of its valley, be called the South-west Branch. This, and the other branches of the North Fork will now be described in brief terms.

The valley of the South-west Branch runs for about four miles in the direction indicated by its name, and for this distance presents a succession of prairie flats, with frequent open, grassy hill-sides to the north. It is in some places nearly half a mile in width. Beyond this point, it is more contracted, and the hills on both sides are wooded, with numerous burnt patches and wind-fall, which obliged us to follow the bed of the stream itself. In this way we travelled a further distance of four miles, attaining a point within less than four miles of the base of the High Rock Range. The stream here became impracticable for our animals, owing to its rocky character, and it had dwindled to a very small size. Having ascended a high hill from which the country to the west was completely overlooked, it was determined not to expend further time and labour in forcing a passage in this direction. This part of the axial range was observed to be an unbroken and wall-like mass of limestone, with an average altitude of about 7,000 feet. To its base, and running out from it at various angles, attach long, steep-sided spurs of Cretaceous rocks, bare of trees, and more or less uniformly covered with grass and low alpine vegetation, their higher portions attaining elevations rather greater than 6,000 feet. They are separated by deep V-shaped valleys filled with dense green woods. Though not extremely rugged, the mountain scenery here, from its varied outline, and the contrasts in colour between the pale limestone peaks, the light-green meadows of the higher slopes and the sombre forests of the hollows, is peculiarly pleasing. South-west Branch. High Rock Range.

Though cutting almost directly across the Cretaceous trough, the geological section afforded by the South-west Branch is not particularly instructive. Immediately west of the edge of the limestone, sandstones Section on South-west Branch.

* For some unknown reason the mountains in this particular region are known to the Indians as the 'Home of the Cold,' *Kis-in-wi-ki* in Cree, or *Ti-sni* in Stoney.

and conglomerates are found dipping westward, but at lower angles than the limestone. For some miles the beds are rather irregular, both strike and angle of dip varying much, so that it would require very detailed work to make out a clear section; they appear, however, to form a synclinal, followed by an anticlinal fold, which is succeeded by a great thickness of beds dipping generally westward at high angles. At a point six miles up the stream, one hundred feet or more of blackish sandy shales occur, the beds being nearly horizontal, and probably resting in a wide synclinal. These may represent the shales which lie several hundred feet above the coal-bearing horizon on the North-west Branch. Beyond this, as far as examined, the rocks have general westward dips at angles of about 30 to 40 degrees. Fragments of Cretaceous volcanic rocks, like those described on the Crow Nest Pass, are found in some abundance in this stream, and it is probable that the beds from which these fragments come, cross the stream at a point higher up than was examined. No fragments of coal were observed in the gravel or wash of this stream.

West Branch. The West Branch joins the North Branch at a point two and quarter miles above The Gap. The valley leaves that of the North Branch at a right angle, and runs nearly due west for ten miles to the base of the watershed range. For three miles it is somewhat narrow and cuts through a series of high sandstone ridges, which strike nearly north-and-south. In this part of its length it is about half-wooded, with many little meadows and grassy slopes to the north. The hills then fall away and become lower, and an extensive prairie, with an area (without counting the grassy slopes of higher hills) of about a square mile, appears on the north side. **Prairie.** This is known to the Stoney Indians by an unpronounceable name, meaning the "Prairie where the Kootanie child died." Thence for about six miles the valley is again rather narrow, but the bordering hills are low, and as viewed from a height, the country is almost plateau-like, and nearly everywhere wooded. This uniformity leads to the belief that the Cretaceous rocks are here little disturbed, **Timber.** which is further borne out by the attitude of the rocks themselves wherever seen. Along the valley is a considerable quantity of timber of fair growth, and very little of it has so far been destroyed by fire. The trees are spruce (*Picea Engelmanni*), black pine (*Pinus Murrayana*) and balsam-spruce (*Abies subalpina*). There are also, along this part of **Gould's Dome.** the valley, numerous open glades with good pasturage for animals. The last of these is situated due south of the summit of a high, rough, limestone mountain, which is in sight from many points during the ascent of the valley, and constitutes a remarkable outlier of the main range. This mountain is supposed to be identical with that seen from a distance by Capt. Blackiston, and named by him Gould's Dome.

On reaching the eastern slope of the main range, the valley turns to the north, and runs between this and the southern spur of Gould's Dome, for two and a half miles. The stream is here quite small, being about ten feet wide by three inches deep, and the valley running on to the north, evidently leads over in a few miles to the North-west Branch. On reaching the point above indicated, the main range is ascended by a series of sharp zig-zags through thick woods, and the summit is crossed by a rough valley, nearly half a mile in width, flanked to the north and south by bare, though rather rounded limestone mountains. This pass, which, as far as I know, had not been traversed, except by Indians, till crossed by us in 1884, may be named the North Fork Pass. The height of the summit is 6,773 feet, the rapid ascent from the brook to the east being about 550 feet. The valley at the summit is for the most part open and grassy, a fact due to the destructive effect of the winter avalanches from the adjacent mountains, rather than to the elevation, which, in itself, is not sufficient to prevent the growth of forest.

Summit on North Fork Pass.

The section of the Crow Nest Cretaceous trough seen on the West Branch, which cuts across its entire width, has a pretty exact parallelism with that on the South-west Branch. It is shown, more or less diagramatically, in section No. 3. The sandstones and conglomerates dip off the west slope of the Livingstone Range, forming first a low synclinal, followed by a couple of low anticlinals. After about two miles, characterized by pretty regular westward dips, another wide synclinal is crossed, beyond which westerly dips were again observed. Opposite the southern end of Gould's Dome, the beds are nearly flat, and a tongue of Cretaceous rocks evidently runs north between this mountain and the main range, though whether this inosculates with the same rocks on the North-west Branch or not is uncertain. Gould's Dome appears to be entirely composed of limestone, with a synclinal structure, while the limestone rocks of the main range dip persistently westward at angles of 40 to 50°. Neither the contemporaneous volcanic rocks of the Cretaceous nor any coal seams were found on the West Branch.

Section on West Branch.

In descending westwards from the summit, the north side is followed of the valley of a stream, most of the way through thick woods, but at one place along the edge of a high cliff of limestone. Here an extensive view is obtained to the south, where rounded and densely wooded ridges are seen succeeding the bare central portion of the main range to the west. Four miles from the summit, the trail reaches the junction of the stream followed, with a second, coming from the north, and about equal in size. The united streams flow then south-westward between gravelly flats, more or less densely wooded, till they

Country between summit and Elk River.

reach the eastern base of a narrow, abrupt limestone range, which still intervenes between this point and the valley of the Elk River. This range, which it is proposed to call the Wī-suk-ī-tshak Range, runs parallel with the High Rock Range, nearly north-and-south. It ends to the northward in about six miles, and to the south may continue for a greater distance. It is cut completely through nearly at right angles, by the stream followed by the trail. The passage thus made is a narrow, rocky defile, bordered by cliffs and crags, and about two miles in length. The trail is rough, and crosses the stream a number of times. A fall of about fifteen feet occurs at one place. After thus passing the Wī-suk-ī-tshak Range, the great valley of the Elk River, here about three miles in width, is entered, and the North Fork Pass may be said to end.

Wi-suk-i-tshak Range.

Rocks between summit and Elk River.

The limestone strata of the western slope of the High Rock Range, dip westward at moderate angles, and are overlain by hard Cretaceous sandstones, which occupy the valley between this and the Wī-suk-ī-tshak Range, with a width of about two miles. So few exposures of these rocks were seen, that their attitude cannot be stated with certainty, but they probably form a synclinal tongue, connected to the north with the main mass of Cretaceous rocks which here occupies the Elk Valley. Rolled fragments of bituminous coal were found in the northern branch of the brook previously described. The Wī-suk-ī-tshak Range shows, where traversed, two anticlinal folds, with an intervening synclinal, and consists of rocks of the limestone series, which here, however, includes a wide zone of brown-weathering quartzite. This, in some places, holds frequent small pyritous concretions, while the limestones are often cherty. The eastern anticlinal in this section is rather low, while the western is slightly overturned on the intervening synclinal.

Character of North Fork Pass trail.

While the traverse above described by the West Branch of the Old Man and across the summit to the Elk has been spoken of as following a 'trail,' it should be explained that it appears to have been very little used as a connected route. We found a moderately well-beaten track in some places, while in others scarcely any vestige of trail exists. This pass might be made part of a through route to the Columbia-Kootanie Valley by utilizing a trail, reported by the Indians, which leaves the west side of the Elk Valley nearly opposite the point at which it enters the same valley from the east. This trail is stated to cross by the head-waters of Bull River to the Kootanie and to reach the latter a few miles above the point at which it leaves the mountains. The impossibility of fording the Elk River, however, at times of high water, would render this route precarious.

The North-west Branch of the North Fork joins the North Branch or Livingstone River at a point five and a half miles north of The Gap. The valley first runs two and a half miles nearly due west, then eight and a-half miles in a general bearing of N. 45° W. to the fall, and finally a similar distance—turning first a little more to the north and then rather to the east of the last bearing—to its termination at the base of the High Rock Range. North-west Branch.

We camped at the upper end of the east-and-west or lower part of the valley on the evening of August 8th, 1883. Up to this point the valley is wide, with open terraces and grassy hill-sides to the north, the stream, where not confined between low, rocky cliffs, being about fifty feet wide by one foot deep, and everywhere rapid. The hills bordering the valley, which are low near the mouth of the stream, become high and bold near the point designated, the valley here cutting through a well marked range, which runs for many miles northward. For about a mile above this point, the valley maintains the same character, but further on becomes more contracted, and generally wooded, with much tangled wind-fall in places and only occasional grassy meadows. On the lower part of this portion of the valley the bordering hills are broken, but further on assume the character of wide ridges, rather plateau-like in aspect, and attaining an elevation of about 1,200 feet above the valley in some places. Two streams, apparently of some size, come in from the southward, and two from the north, one about six, the second about fifteen feet wide. The trail—a Stoney Indian hunting-track—follows the left or north-east bank. Character of the valley.

The fall is about thirty-five feet in total height, and notwithstanding the quantity of standing and fallen burnt woods with which the hills are here covered, its surroundings are very picturesque. A valley, carrying a stream of some size, opens from the south-west just above the fall, and affords a grand view of the limestone mountains of the watershed range, here about two and a half miles distant. Though the peaks in the vicinity scarcely exceed 8,000 feet above the sea-level, their forms are singularly bold and varied, one of the nearest culminating in vertical, organ-like columns. A round-topped mountain, much resembling the Crow's Nest in outline, standing a little in advance of the main range and higher than it, has an elevation of about 8,500 feet. This is about four and a half miles west-north-west of the fall, and, on account of its peculiar form, may be called Bee-hive Mountain. For the benefit of future travellers, I may add that there is an excellent camping ground, with good pasturage, just above the fall, while the deep pool below is a good fishing place. Valley near the fall. High Rock Range.

Upper part of valley.

The weather being extremely wet, and the valley above apparently very much encumbered by wind-fall, Mr. Tyrrell, my assistant in 1883, proceeded on foot in search of a practicable route to the head-waters of the main stream, while I ascended a high hill to the south of the fall, for the purpose of sketching the topography and gaining such knowledge of the region as the clouded condition of the atmosphere would permit. Having ascertained that the upper part of the valley was not so difficult as had been supposed, we travelled the next day almost to the base of the High Rock Range, and there choosing another observation point on a high spur of the range, obtained sketches and bearings of the whole surrounding country.

A high sandstone and conglomerate ridge, which abuts on the valley at the fall, runs boldly northward, and was again recognized on the head-waters of the Highwood, sixteen miles distant. Beyond this ridge, the valley is continued in a north-westward direction for about five miles, cutting very obliquely across a series of parallel strike-ridges. This part of the valley contains several grassy glades, but is frequently obstructed by burnt and fallen timber. The valley then turns westward, cutting almost directly across the strike, and becoming at the same time, for about two miles, quite open, with low bordering ridges, or plateau-like elevations. The stream, reduced to a mere brook, winds through swampy meadows with thickets of *Betula glandulosa* and other northern forms. The immediate foot-hills and slopes of the limestone range are encumbered here with dense and nearly impenetrable wind-fall. Beyond, rise the almost absolutely bare and precipitous fronts of the main range, down which little cascades, forming the furthest sources of the Old Man, are observed to fall. From the north, no less than five streams join that of the main valley above the fall, with but one of any size from the southward. For about a mile, near the point at which the valley first turns westward, the stream itself flows between low rocky cliffs in the bottom of the valley. By the valley of the second stream from the north above this miniature cañon, we subsequently found a route to the southern feeders of the Highwood. The stream itself was named Oyster Creek, on account of the occurrence on it of banks strewn with fossil shells of this kind.

Geology of North-west Branch.

While the geological features, observed in crossing the Crow Nest Cretaceous trough by the North-west Branch, are largely a repetition of those already described on the more southern branches, and the obliquity of the general course of the valley to the strike, renders the section more obscure than on these, some points deserve special note. The sandstones and conglomerates, met with near the junction of this stream with the North Branch, dip uniformly westward from the flank

of the Livingstone Range. Between the Livingstone River and our camp of August 8th, above alluded to, two and a half miles west, the beds form a low synclinal, followed by a similarly low anticlinal, and at the point just designated, are found dipping S. 30° W. < 50°, and including seams of coal. The section shown in the bank at this place is as follows in descending order.— Coal seams.

	FEET.	INCHES.
1. Superficial gravels	—	—
2. *Coal*	1	0
3. Shale	0	1
4. *Coal*	2	6
5. Shale	0	4
6. *Coal*	5	6
7. Shale	0	6
8. *Coal*	0	9
9. Sandstone	2	0
10. Shale and coal	2	0
11. Sandstone and shale	2	0
12. Black shale	1	6
13. Sandstone	2	0
14. Black shale with coaly layers and some ironstone	9	0
15. Clay-shales and ironstone (to water)	6	0
	35	2

The total thickness of coal in the section is thus nine feet nine inches, but the top of the upper part of the seam is wanting. The coal is generally crumbling and soft, a circumstance, doubtless, largely due to weathering, though the numerous small cracks and slickensided surfaces observed show that it is naturally tender. Like some other coals in the mountain region it has probably been crushed by movement of the beds subsequent to its complete consolidation. Mr. Hoffmann's analysis of this coal shows it to be of excellent quality. It yields a firm coke, and contains water 1·24, volatile combustible matter 24·62, fixed carbon 66·61, ash 7·53. (See p. 9 M.) Coal.

A few fossil plants were collected which proved sufficient to show by the identity of species, that the coals here met with must be regarded as being in the same stratigraphical position as those described in the Crow Nest and South Kootanie passes. All these localities indeed, probably represent a single, persistently coal-bearing horizon. From this point to the fall no satisfactory general section was obtained. Fossil plants.

Less than half a mile below the fall, coal is again seen in the bank of the stream, associated with sandstones, ironstones and black shales. These rocks likely constitute another repetition of the horizon just referred Second coal outcrop.

to. The coal is here, however, almost completely pulverized and the section much compressed. The greatest observed thickness was about three feet. Strike S. 20° E. with a westward dip at an angle of about 60°. The fall is produced by massive sandstone beds associated with conglomerate, which cross the stream and probably hold a higher place in the series than the coal. Three miles above the fall, at the mouth of a considerable stream from the north, a bed of grey ash rock appears. The strike is about N. 17° W., and about twenty feet in thickness is shown. The exposure is a small one, but it appears probable that nearly the entire thickness of the bed is exhibited. The material, which, though properly speaking, an ash rock, might almost be called in places a fine-grained agglomerate, is evidently the representation here of the thick volcanic zone previously described on Crow Nest Pass. It resembles the similar rocks already noticed in being somewhat calcareous, and in the absence of quartz grains. This is the furthest point to the north at which rocks of this character were recognized in the Cretaceous, and they are here evidently dying out, the point of eruption having probably been not far from the Crow Nest Pass.

Volcanic rocks.

Plant-bearing beds.

The beds underlying the volcanic material, at less than a quarter of a mile up the same small stream, dip pretty regularly S. 58° W. at angles of 40° to 45°. They are greenish-grey, flaggy and shaly sandstones, with some blackish and reddish sandy shales and occasional conglomerate layers. Some of these beds yielded a number of fossil plants, which though imperfectly preserved, are stated by Sir J. W. Dawson to have important points of resemblance with those of the Dakota group, and to represent the same horizon as that from which plants were obtained near the mill on Mill Creek, in the foot-hills.* The following species were recognized.—†

Alnites insignis, (?) Dn.
Platanus affinis, Lesq.
Macclintockia Cretacea, Heer.
Laurophyllum debile, Dn.
Aralia, sp.
Paliurus montanus, Dn.
Juglandites Cretacea, Dn.

Thickness of strata.

The zone at which the plants occur was estimated to be about four hundred feet below the volcanic rock. By plotting the attitudes of the rocks intervening between the latter and the coal outcrop below the fall, the coal was estimated to be, approximately,

* See Report of Progress, 1882-84.
† Trans. Royal Soc. of Canada, Vol. III., Sect. IV.

2,200 feet below the same horizon, a thickness considerably less than that of the volume of strata between the horizons believed to be the same in the Crow Nest Pass. In the same brook coal fragments are found, and it is probable that the continuation of the coal seam is cut through not many miles further up.

Dark shales.

For about two miles above this occurrence of volcanic rock, the valley nearly follows the course of a series of black or dark-grey shales, with sandy beds not infrequently intercalated and some layers of ironstone. These have a thickness of at least 1,400 feet, and overlie the ash bed. A few fossils obtained from them appear to show that these shales represent the Benton group. Mr. J. F. Whiteaves has recognized among these *Inoceramus undabundus, Pholadomya papyracea, Scaphites Warreni and S. vermiformis ?**

Highest beds of section.

If the section still continues a regular one, in ascending order, the beds of the cañon-like part of the stream, above described, should represent the Belly River series of the plains. They are flaggy, hard and soft sandstones, with shaly layers, but all of rather pale colour. The dip is here S. 63° W. < 25°. If the Pierre shales follow these, they are passed over in the part of the valley without exposures. The sandstones nearest the base of the mountains are probably Laramie, as they are on the strike of those observed a few miles up Oyster Creek, which are known by their fossils to be of that age. They dip at low angles toward the mountains.

Livingstone River.

The valley of the North Branch or Livingtone River, is remarkably straight and runs nearly due north from The Gap. In its lower part it is in some places a mile wide in the bottom, and averages fully half a mile in width for a long way up. Its general aspect is very attractive. About half the area of the valley may be designated as bunch-grass prairie and meadow, and the soil is good, though evidently unfitted for cultivation, owing to the frequency of summer frosts, due to the altitude and proximity of the mountains. The vegetation resembles that of the foot-hills to the east. At a point about eighteen miles above The Gap, however, the characters change. The stream, which in its lower part generally occupies a rather deep channel in the valley-bottom, is here reduced to a small rapid brook, and its bed is little depressed. The flats are rough and stony, and the vegetation becomes sub-alpine. Swamps are frequent and hold a thick growth of willows and *Betula glandulosa*, while the woods consist of *Pinus Murrayana* and aspen, with a few Douglas firs, cottonwoods and Engelmann's spruce. The valley was followed up to a point nearly twenty-three miles from The Gap, where it bifurcates, the main stream—a brook

* See Contributions to Canadian Palæontology, Vol. I., Part I.

twenty feet wide by six inches deep—coming from the north-westward through a narrow valley, while a trail going northward by a second valley crosses by an elevated pass to the head-waters of the Middle Branch of the Highwood in the foot-hills (see p. 94 B).

Livingstone Range.

The Livingstone Range, composed of limestone, constitutes the eastern side of the valley of the Livingstone River, while the Cretaceous rocks form the hills on the west. The stream flows, however, till near its head, altogether on the Cretaceous, the junction between the two series lying close in to the abrupt base of the limestone mountains. These are in general very steep, with much bare rock, scarps, cliffs and screes. The higher points rise about 2,000 feet above the valley, while the sandstone hills seldom attain 1,500 feet and are generally not more than 1,000 feet. The slope of the valley itself is considerable, yet the higher points of the hills and to a less degree of the Livingstone Range also, seem throughout to preserve about the same elevation relatively to it. The limestone range is most rugged in its southern half, and though generally showing westward dips, in places exhibits eastward ones. Northward, the summits of these mountains are generally rounded and bald, and evidently composed of rock crumbled in place.

Break in the range.

Though thus far spoken of as continuous, the Livingstone Range is interrupted for a distance of probably three miles, at a point about ten miles north of The Gap. The stream here turns away from the base of the range and for some miles is bordered on both sides by Cretaceous hills, which are continuous to the east with those of the outer foot-hills. Where the limestone range resumes, it appears to represent a distinct anticlinal fold, the axis of which lies further to the east. One tributary from the east flows completely through the Livingstone Range, while two others enter through the break above referred to. The larger tributaries, however, come from the westward, of which the West and North-west Branches, previously described, are the most important. Another rapid stream —seventeen feet wide by six inches deep,—enters from the west, twenty miles from The Gap, and near this point the edge of the limestones turns westward, the strike changing to the same direction. The Cretaceous hills to the south of the stream are steep and escarpment-like, and constitute the end of a well-marked high range, which runs southward about ten miles, parallel to the main valley and a few miles west of it. The sandstone hills, of which this constitutes a part, form a broken, irregular country, with narrow valleys and are almost uniformly wooded. The forest has not been much destroyed by fire, but the timber is only of fair quality and not very large in size.

Twenty-mile Creek.

The limestone of the Livingstone Range, as far as examined, appears chiefly to resemble that of the upper cherty beds of the Crow Nest Lake,

though there is also some crinoidal limestone. The banks of the Livingstone River show fine sections of Cretaceous rocks, though, as the stream nearly follows the strike, the same zones constantly recur. Grey or brown sandstones, sometimes rather massive, alternate with coffee-coloured, or bottle-green, crumbling and shaly sandstones, and occasional beds of ironstone. For about three miles above the entrance of the North-west Branch valley, the Cretaceous rocks are much disturbed, and are in places nearly on edge. Rocks of Livingstone Range.

In the wash of a stream entering at fifteen miles from The Gap, and again in that of the Twenty-mile Stream, above alluded to, fragments of coal occur, and it is probable that closer investigation will bring to light a number of coal outcrops in the vicinity. The lower part of the Livingstone Valley shows in many places thick beds of rounded gravel overlying the Cretaceous; and narrow terraces occur several hundred feet above the stream in some localities. In the upper part of the valley a deposit resembling boulder-clay, and charged with large sub-angular limestone blocks appears, forming terraces eighty feet above the stream. No glaciated stones were, however, found, nor were any striated rock-surfaces observed. The gravel of the streams is remarkably local in origin in all this part of the mountains, and there is little apparent evidence of extensive glaciation. Coal. Gravel deposits.

The following are the elevations of some points on the branches of the North Fork of the Old Man River, within The Gap, barometrically determined, and in each case referring to the water-level of the stream :— Elevations.

NORTH-WEST BRANCH.—Eight miles from Gap (2½ miles above mouth of this branch) 4,966 feet. Above the fall, 5,512 feet. Near source, about half a mile from base of main range, 6,311 feet.

LIVINGSTONE RIVER OR NORTH BRANCH.—Two miles from Gap, 4,709 feet. Sixteen miles from Gap, 5,371 feet.

Head-waters of the Highwood River.

The southern sources of the Highwood River were reached by following up the tributary of the North-west Branch of Old Man River, which has already been alluded to under the name of Oyster Creek. The trail followed, which is rather an Indian hunting-track than a regularly travelled route, crosses and re-crosses Oyster Creek and small streams joining it, till about four and a half miles from the valley of the North-west Branch, the watershed between this and the Highwood is crossed, and Lost Creek, a tributary of the Cataract Branch of the Highwood, is reached. Oyster Creek and Lost Creek flow in opposite Trail to Cataract Branch.

directions in a persistent valley, with a nearly north-and-south bearing, which lies along the base of the westernmost of the series of parallel Cretaceous ridges which characterize the country between the Livingstone and High Rock limestone ranges. This valley is at an average distance of about three miles from the crest of the latter range, and is separated from its base by irregular wooded hills. The High Rock Range, though here sinuous with regard to the line of its crest, is continuous and wall-like toward the east, and crowned at intervals by bare, rugged summits of irregular and striking forms. The limestone rocks composing it have a persistent westward dip and several high, bare, flat-topped ridges project eastward from its base.

Oyster Creek. In following up Oyster Creek, the country is generally wooded, though the trees are, as a rule, small, and there are numerous little meadows in the valleys. The elevation of the summit is 6,226 feet, and the country gradually descending northward from this point is densely wooded, though the trees are here also usually not of great size. The first little prairie occurs at about three miles from the summit. At six miles from the summit, this tributary of the Cataract Branch, abandoning its northward course, turns abruptly eastward.

Laramie rocks. The valley follows the general strike of the rocks throughout. Near the head-waters of Oyster Creek, sandstones and shales, generally of a soft character, are well exposed in the banks, and dip nearly due west at angles of 45° to 50°. A massive bed also occurs, which is composed almost entirely of oyster shells, and exactly resembles some of those seen in the eastern foot-hills near the 49th parallel. (See Report of Progress, 1882-84, p. 55 c.) They are overlain by soft shales and sandstones, holding coal-seams, of which the thickest observed is about two feet. Just north of the watershed, the same coal-bearing horizon is again seen in several places, and though the seams are here all quite thin, it is not impossible that thicker ones might be found in this vicinity.

Coal. The coal found at this place is a true bituminous one, yielding a firm coke, but a specimen examined contained 24·69 per cent. of ash. (See Report by Mr. Hoffman, p. 8 M.)

Fossils. The *Ostrea*, above referred to, has been determined by Mr. Whiteaves to be *O. glabra*, var. *Wyomingensis*. *Corbicula occidentalis* occurs in the same bed in smaller numbers, and silicified wood is also found. The horizon is almost certainly near the base of the Laramie, and the locality is interesting as being almost the only one in which beds of this age have been clearly recognized in the mountains. The greater part of the space between the valley of Oyster and Lost creeks and the base of the mountains, may be underlain by these rocks.

Another point of interest is the entire absence of gravel deposits about the summit between Oyster Creek and Lost Creek, where even the smallest rills cut channels into the beds above described. Lower down on both streams, gravelly and other detrital deposits are met with in the usual abundance, and include much limestone from the adjacent mountains. Absence of gravel deposits.

The part of the valley of the Cataract Branch, into which Lost Creek falls, runs nearly east-and-west from the base of the High Rock or watershed range to the outer Highwood Range, which forms a northern continuation of the Livingstone Range. Its western extremity rises rapidly toward the base of the High Rock Range, and is wide and shallow, bounded by low-wooded hills, with open alpine meadows toward the higher levels. Eastward, it becomes a deep trough, and cuts directly across five or six high Cretaceous ridges. Of these the most important is the central one, which attains a height both to the south and north of the valley, of about 2,000 feet above it. The point to the north, which was ascended, affords a very fine view of the upper east-and-west part of the valley of the Cataract Branch, which has a length of about eight miles, and the contrast is very marked between the high parallel ridges, characterizing the eastern part of the Cretaceous area, with the gentle flowing outlines of the hills forming a belt of several miles along the base of the High Rock Range. This difference is no doubt dependent on the different attitude of the rocks, which in one case form a series of sharp folds, in the other, whether in this normal position or—as may very likely be the case—completely inverted, lie at comparatively low angles. Country near Cataract Branch.

The east-and-west portion of the Cataract Branch valley contains many patches of prairie along the stream, and these often run up on the southward-facing slopes to a considerable elevation. The woods are not much destroyed by fire, but the size of the trees is small. At the foot of the Highwood Range is a rather large, triangular, flat, terraced area, in which a small stream—Salter's Brook—coming from the pass which leads across the range to the eastern foot-hills, joins the river. It was our intention to follow the river now called the Cataract Branch to its junction with the main Highwood, but about two miles below the mouth of Salter's Brook, the valley, running northward along the base of the Highwood Range, becomes narrow and densely wooded, and we came abruptly to the edge of a gorge, into which the river plunges, making a picturesque fall, the upper leap of which is about ten, the lower about thirty feet. Finding no vestige of a trail beyond this point, and the character of the valley rendering it evident that it would be difficult if not impossible to take our animals further, we turned back to Salter's Brook and crossed the Highwood Range. Cataract Branch valley. Fall.

Cretaceous rocks.

No features of special geological interest were observed during the traverse of this part of the Crow Nest Cretaceous trough. The strike of the rocks varies from N. 34° W. to N. 22° W., and the dips are almost uniformly to the south-west at very high angles, the beds becoming vertical in some places. Two considerable belts, characterized by dark shales and shaly sandstones, cross the east-and-west part of the Cataract Branch valley. One about a mile wide, just east of the mouth of Lost Creek, the other, probably less important, about a mile above the mouth of Salter's Creek. The remaining rocks are sandstones with some conglomerate, which are often considerably indurated and weather to a brownish colour. Each of the shale belts probably consists of several compressed folds, giving an appearance of very great thickness. The first or western belt is apparently continuous with that described on the North-west Branch of the North Fork (p. 89B).

Limestone series.

Just above the fall, the limestones of the Highwood Range first appear on the river with a dip of N. 82° W., at an angle of 5°. These limestones weather brownish, and have the appearance of the beds of this series frequently found immediately underlying the Cretaceous. At the fall, the limestones are of the usual blue-grey colour, and dip S. 73° W. $<$ 20°. The limestones of the western part of the Highwood Range dip westward at angles of 35 to 40 degrees, and as this is nearly the slope of the mountain sides, wide, flat surfaces of bare rock are exposed.

Pass over Highwood Range.

In following Salter's Brook eastward, toward the summit of the pass over the Highwood Range, it is soon found to become a rough stony torrent-bed, which we were obliged to cross and re-cross. The valley is now contracted and the mountains rise abruptly on either side to a height ofa bout 2,000 feet. The summit is reached at about four miles after leaving the Cataract Branch, and has an elevation of 6,398 feet. The descent to the east is at first very steep, and leads down into an amphitheatre, open to the north, and bounded to the east by Sentinel Mountain, which forms a high projecting spur of the limestone range. The scenery is of a wild alpine character, and several streams from the encircling mountains fall toward the centre of the great depression, forming the sources of the Middle Branch of the Highwood River. There is probably here a synclinal fold of Cretaceous rocks, compressed and overturned between the limestone masses forming the range just traversed on one side and Sentinel Mountain on the other. The Cretaceous rocks are, however, much disturbed and irregular, and the synclinal runs out to the southward against a high irregular mass of limestone mountains, across which, we were informed, an Indian trail runs to the head of the Livingstone River. It is a somewhat remarkable fact that the sources of Salter's Brook are actually on the Cretaceous sandstones

to the east, and that it runs completely across the limestone belt of the Highwood Range. This circumstance shows, that when hardened, the Cretaceous sandstones are capable of affording to denudation a resistance as great as the older limestone series.

From its source, the Middle Branch of the Highwood runs in a direction a few degrees east of north for seven miles, beyond which point it turns eastward. The valley is at first deep and shut in by high, steep foot-hills, but as it gradually recedes from the base of the Highwood Range, it becomes more open. Successive fires have almost entirely removed the wood from the upper part of the stream, and the slopes have become grassed, with the irregular, scanty growth often observed in the high and bleak parts of the foot-hills. Before reaching the point at which this stream bends eastward, however, several luxuriant prairie patches interspersed with coppice are passed through. No detailed examination of the Cretaceous rocks of this part of the foot-hills was made, but an important band of dark shales appears nearly to follow the upper part of the stream and running across the intervening country to the main stream of the Highwood, gives rise to a wide, low valley. Middle Branch of Highwood River.

The foot-hills, bordering the Highwood Range in this vicinity, run out in a series of long, comb-like spurs, nearly at right angles to the range, and to the general direction of strike. This peculiarity, which is again referred to, is in marked contrast to the usual system of strike-ridges met with in the foot-hills and other folded Cretaceous areas. It would appear that where the Cretaceous rocks form the flanks of a dominant range, the streams, for some reason, tend to follow lines of transverse fissure rather than the strike. Comb-like foot-hills.

Following up the so-called North Branch of the Highwood, which is in reality the main stream, we again entered the mountains, eight miles north of the pass just described. The Highwood Valley, in the foot-hills adjacent to the mountains, is a wide depression, with prairie flats and terraced sides. The hills near it are from one-half to two-thirds wooded. chiefly with aspen, but much of the wood is dead and blackened by fires. Highwood Valley.

The gap, or gorge, by which the river leaves the Highwood Range, is narrow, the elevation of the river at this point being about 4,780 feet. The Cretaceous rocks east of the range dip toward it, or westward, at angles of 30° to 35°, but on approaching their junction with the limestone, become vertical and show evidences of very great pressure. The line of junction appears to follow the crest of a high ridge for some distance south of the river. The limestone series forming the Highwood Range has, on the river, a transverse width of about two miles, and probably presents the usual anticlinal structure as the dips are westward, and the limestones are again followed to the west by the Cretaceous series. The Highwood Gap.

mountain mass to the north of The Gap, of which only the high spurs are seen in following the river, I take to be Mount Head, of the maps. A mountain with this name appears on Palliser's map, and has been given great prominence on several more recent maps, but I have been unable to ascertain by whom the name was applied, or to find any description or bearings by which it might be satisfactorily identified. It may probably have been a peak seen from the eastern plains or foot-hills at a great distance. Its latitude, and position in the eastern range of the mountains, as shown on Palliser's map, accord nearly with the mountain here referred to, and under the circumstances there is no reason why the name should not be preserved in connection with this mountain, even if it be not that originally intended.

Mount Head.

Change in trend of range.

The Highwood River breaks through the outer range at a point at which the latter suffers a marked change in trend, running more to the north-westward, and making an angle of nearly fifteen degrees with its former general course. The High Rock Range to the west, and the intervening Cretaceous ridges of the northern part of the Crow Nest Cretaceous trough, participate in this changed trend, which must therefore be of some structural importance.

Highwood Valley in the Mountains.

Within the Highwood Range, the river-valley runs westward for about two miles, crossing a series of Cretaceous ridges, like those seen on the corresponding portion of the Cataract Branch. The rocks, so far as exposed, are usually sandstones, varying in texture, and in colour from yellowish and brownish to greenish-grey. The dips are westward at an average angle of about 60°.

From the point last mentioned the valley turns to the north-westward, occupying nearly the centre of the Cretaceous area between the two limestone ranges, for a distance of twelve miles, when, by the interpolation of a third range of limestone mountains, of which Mist Mountain constitutes the southern extremity, the Cretaceous trough is divided into two branches, the stream at the same time bifurcating. The western branch—Storm Creek—occupies a valley which runs across to the Kananaskis, the eastern—Mist Creek—rises six miles north from the forks at the base of a high transverse ridge formed by the inosculation of the foot-hills of the Mist and Highwood ranges.

Character of the valley.

From The Gap to the forks, near Mist Mountain—a distance of fourteen miles—the valley contains a number of prairie patches, but becomes more generally wooded on toward the forks. The river at the forks has an elevation of 5,736 feet. The hills on both sides are, as a rule, rather densely wooded, and several small tributary streams fall in, both from the Highwood and High Rock ranges. About six miles up the river from The Gap, an indistinct trail, which we had followed so far, was lost, and in trying back, we fell upon an old trail,

which for about three miles, runs parallel to the river, behind a low intervening ridge. This trail, though now obstructed by wind-fall, has evidently at one time been much travelled, and, I believe, formed part of the north and south 'pitching trail' of the mountain Indians.

The Cretaceous hills to the east of this part of the river are high and rough and are broken at intervals by torrent-valleys which bring down the waters of the Highwood Range. This range was here not well seen, but so far as observed, the limestones appear to dip southward at high angles. In the High Rock Range, on the contrary, the limestones lie at comparatively low angles, though dipping in the same direction. The hills intervening between the river and the High Rock Range, are again comparatively low and gently rounded, and are densely wooded. The range itself resembles in character that near the head-waters of the North-west Branch of the Old Man, and has some summits with remarkable block-like forms. One very high, pointed mountain is nearly on the latitude of the Highwood Gap.

Pass between Highwood and Kananaskis.

In following up Storm Creek ten and a half miles, between the Misty Range and a parallel range on the west, a summit separating the waters of the Highwood and Kananaskis, is reached. The valley is continuous and straight, and the Kananaskis Valley, at a distance of about four miles, may be seen from it. This summit, which has a height of 7,217 feet, is very nearly in the same latitude with that between the Kananaskis and the Elk (p. 107 B), and only three and a half miles distant from it, with one intervening range. Bearings were obtained from this point on mountains previously fixed on the Kananaskis, but my examination was not carried beyond the summit.

Storm Creek.

Storm Creek, is really the main source of the Highwood, and carries nearly twice as much water as Mist Creek. The valley is generally wooded, and is rather narrow and rough for a few miles above its mouth, after which it becomes wide and flat bottomed, and runs parallel to the enclosing ranges. The woods have not yet been much destroyed by fire, and some trees of very fair growth occur in the upper part of the valley. The elevation becomes such before the summit is reached, however, that the valley assumes an open alpine character, with scattered groves of larch (*Larix Lyallii*), and the slopes rising above it are there quite bare of wood. Near its mouth, the Cretaceous hills on the south are very high and irregular. Though the height of these hills and the bad weather prevailing at the date of our visit, prevented certainty in the matter, there is every appearance of a break in the main range in this vicinity, and it is possible that one of the larger tributaries of the Elk may rise tc the east of the range. Beyond the position of this supposed gap, the limestone range to the south-west is very high and broken. At the summit of the pass, a high Creta-

ceous ridge intervenes between the stream and these mountains, while the bare limestone slopes of the Misty Range rise on the opposite side. Fragments of coal were observed in the stream a few miles south of the summit of the pass. On the night of the 16th of July, 1884, we experienced a heavy snow-storm in the pass, the snow being four inches deep the next morning.

Mist Creek. Mist Creek, for six miles above the forks, runs in a straight north-west and south-east valley, receiving one large brook from the east and three or four from the west. In the lower part of the valley **Good timber.** and in the adjacent hills is a considerable quantity of good timber, consisting principally of spruce and black pine (*Picea Engelmanni* and *Pinus Murrayana*). This might be run down the stream at high stages of the water. The straight valley is eventually blocked by the fusion of the high Cretaceous hills which form the basal ridges of the Misty Range on one side, and the Highwood Range on the other. Turning abruptly to the west at this point, the source of the stream is reached in about a mile and a half, in a profound amphitheatre or cirque, at the base of the first-mentioned range. The floor of this amphitheatre consists of green, alpine meadows and slopes, with scattered clumps of Lyall's larch. Its elevation is 7,266 feet. As it proved impossible to go further in this direction, we returned down the valley to the point at which it bends, and climbing the bare ridge, found ourselves eventually on a narrow crest, at an elevation of 7,632 feet, with a practicable though steep and rough descent on the other side, to the valley of Sheep Creek.

FIG. 3. MIST MOUNTAIN FROM THE SOUTH.

Mist Mountain. Mist Mountain, with an elevation of about 10,000 feet, is one of the highest summits in this region. It occupies a position of peculiar prominence, forming the prow-like, south-eastern extremity of the massive limestone range which separates Storm and Mist creeks. It is singularly bold and precipitous, and, as seen from the southward, rises in the centre of several high spurs composed of Cretaceous rocks, which surround it on three sides, and about their bare tops have a reddish

aspect which contrasts with the grey of the limestone cliffs of the culminating peak. To the north it attaches to other mountains of the range not much inferior in height, which, as they widen northward, become more or less separated into two parallel subordinate ridges, between which the furthest source of the Elbow River appears to rise. The Misty Range is exceedingly rugged and bare in its southern part, both on the side facing Mist Creek and that toward Storm Creek. The foot-hills of Cretaceous rocks lying between Mist Creek and the range, again show the remarkable comb-like structure previously alluded to, the ridges in this case are sharp-edged, with wide intervening valleys which have semi-circular outlines in cross section. This feature is illustrated in the accompanying plate, on which the ridges to the right and left of the view (with birds shown near them) are of Cretaceous rocks.

Misty Range.

Bifurcation of Cretaceous trough.

As already indicated, the head-waters of the Highwood proper, as well as those of the Cataract Branch, are included in the northern continuation of what may still be designated as the Crow Nest Cretaceous trough. Between the bounding limestone ranges, from the Highwood Gap to Mist Mountain, the Cretaceous rocks have a breadth of about six miles, and so far as observed in most places, maintain their usual westward dips. Further north, the trough is split into two long arms, the limestone mass of the Misty Range separating these. The western arm, or that occupied by the valley of Storm Creek, gradually narrows, and at the summit of the pass is only about a mile and a half wide. In the lower part of the valley, high Cretaceous ridges appear on both sides, but further up this valley, and down that which slopes toward the Kananaskis from the further side of the pass, there is but a single Cretaceous ridge, and this borders the western range. The Cretaceous rocks on this side of the valley dip at angles of 25° to 40° toward the limestones of the Elk Mountains, which may possibly rest upon them in the form of an overturned anticlinal. Those on the east side of the valley very generally dip eastward at rather low angles, and appear to abut against the nearly vertical limestones of the Misty Range along the line of a fault, as shown in the annexed diagramatic section. The extremity of this branch of the Cretaceous

Rocks on Storm Creek.

FIG. 4. DIAGRAMATIC SECTION NEAR THE HEAD-WATERS OF STORM CREEK.

rocks seems to run out completely behind the range fronting on the Kananaskis.

Rocks on Mist Creek.

The Misty Range is with little doubt a great compressed anticlinal of limestone, overturned eastward. The evidence of this structure is perfectly clear on both sides of the cirque at the head of Mist Creek, where the Cretaceous shales and sandstones pass beneath the limestones at an angle of about 40°, and to the east of them are thrown into a series of overlapping folds, more or less fractured. This structure, as shown in the south side of the cirque, is illustrated in the accompanying cut, in which the rocks of the steep slope to the right are limestone. It is of interest in connection with the probable analogous crumpling of parts of the Cascade coal basin, further north.

FIG. 5. OVERTURNED FOLDS OF CRETACEOUS ROCKS AT JUNCTION WITH LIMESTONE, MIST CREEK.

The western branch of the Cretaceous trough, along which Mist Creek runs, is still about two and a half miles wide at the source of the stream, and, as subsequently noted, runs up the valley of Sheep Creek nearly to the Elbow River.

Coal.

That coal occurs in greater or less quantity, pretty generally distributed throughout the Cretaceous rocks of this region, is evidenced by its constant appearance in the streams in rolled fragments. In addition to the places of such occurrence already noted, it was found in several small tributaries of Mist Creek. Seams a few inches thick, were seen in place in the ridges near the head of the creek, and more complete examination might lead to the discovery of workable deposits.

Head-waters of Sheep Creek and Elbow River.

Pass from Highwood to Sheep Creek.

In travelling northward in this part of the range, it was our object to fix the limits, as definitely as possible, and trace to its northern extremity, the great Crow Nest Cretaceous trough. Having been unable to secure the services of any Indian acquainted with the region, we were obliged to select for ourselves what appeared to be the best routes,

GEOLOGICAL SURVEY OF CANADA

G. M. D. PHOTO. JULY 30 1884

British American Bank Note Co. Montreal

SOURCE OF THE NORTH BRANCH OF HIGHWOOD RIVER ROCKY MOUNTAINS.

SHOWING LIMESTONE STRATA OF THE MOUNTAINS [illegible]

a circumstance resulting in some loss of time, and on several occasions causing us to fall into very rough, impracticable country. We had anticipated striking the Elbow River beyond the sources of Mist Creek, but on attaining the summit of the pass, saw at once that the head-waters of Sheep Creek were interposed. From this summit to Sheep Creek, a rapid descent of about 2,600 feet was effected, and the valley reached at a point at which it makes nearly a right angle, the upper part trending north-westward, parallel to the general direction of the mountains, the lower turning to the east and breaking across the outer range toward the foot-hills. From this point to that at which Mr. McConnell* examined Sheep Creek westward, in the foot-hills, a space of nearly twelve miles remains unexplored. The outer or eastern limestone range is here either much wider than usual, or there is an additional echelon range contiguous to it. A couple of miles below the point at which we reached the valley, is a mountain of which the northern side presents a remarkable, sheer cliff, about 2,000 feet in height.

Sheep Creek is here a rapid stream, about thirty feet wide by six inches or a foot deep. The valley is rather wide and flat bottomed, and rises pretty rapidly for five miles, till the source of the stream is reached, on a high plateau overlooking the deep, transverse valley of the Elbow River, at an elevation of 6,877 feet. The whole upper valley of Sheep Creek has been devastated by forest fires, which, in some cases have recurred till the trees have been entirely removed, grassy flats or slopes encumbered with stumps and fragments of burnt trees taking their place. In others, the blackened or bleached trunks are still standing, and the effect is desolate in the extreme. **Sheep Creek.**

The limestones of the mountains on the north-east side of this part of the valley, dip with great regularity to the south-westward, at an angle of about 40°, and the Cretaceous rocks are seen in one or two places to overlap them with apparent conformity. On the opposite side, the Cretaceous constitutes the foot-hills of the northern part of the Misty Range. At a distance of two miles from the Elbow River, the Cretaceous trough still has a width of nearly two miles, but between this point and the river, having now become a thin, superficial sheet, it bifurcates. The western branch extends to the edge of the Elbow Valley, and is evidently cut off by it, though there is some appearance of a very narrow fold of the same rocks engaged high up in the east side of the mountain to the north. Loose fragments of coal were seen in the bed of Sheep Creek, and it is of interest to note that it is here assuming an anthracitic character. **Rocks on Sheep Creek.** **Coal.**

* See Report of Progress, 1882 84, p. 106 c.

Head of Elbow River.

The head-waters of the Elbow River occupy one of the remarkable valleys so frequently found in this part of the Rocky Mountains, which lie exactly at right angles to the trend of the constituent ridges and strike of the rocks. The valley in this case terminates abruptly about two miles west of the source of Sheep Creek, at the base of a very high and rough limestone range, which separates it from the Kananaskis. Two streams converge at this point. That from the south, which drains the central valley of the Misty Range, is evidently the larger. The second, coming from the north or north-west, is said by Indians to afford a rough pass to the Kananaskis. Below the junction of these two streams, the valley is remarkably wide and flat, and as seen from a height, contrasts curiously with the very rugged surrounding mountains by which it is almost enclosed. The scenery is grand, and would be beautiful, but for the fact that the forests have been almost entirely destroyed by fire. Ridges which appear to be moraines, occur in this part of the valley, and further down, glacial striæ were observed following its direction.

Valley of Elbow River.

The lower part of the valley is narrower than the upper, and a well-beaten, though rather rough and hilly trail leads down it, along the bank of the stream. The woods are in some places dense, and the mountains bordering it are often abrupt and cliff-like, though not remarkably high. About two miles before reaching the outer edge of the limestone range, a wide wooded valley opens southward, and from this point, that of the Elbow trends northward. The total length of the transverse valley occupied by the Elbow is about eight miles. At the eastern edge of the limestone ranges, where the stream issues into a low region among Cretaceous foot-hills, the river bed is nearly a quarter of a mile wide, and consists at low water, chiefly of dry, gravel bars. It is evidently subject to very heavy floods.

Rocks on Elbow River.

The rocks forming the mountains on both sides of the portion of the Elbow above described, are, so far as could be observed, entirely of the great limestone series. At the point at which the trail from Sheep Creek reaches the Elbow, they dip south-westward, at an angle of about 40°, but flatten out further down the valley, and appear to lie in a series of light undulations with low dips. At the outer range they are again found dipping in the direction just noted, but at an angle of about 25°, and the first Cretaceous rocks seen to the east have a similar dip, and in the same direction. Whether this circumstance is here due to overturned folding, or to faulting, is uncertain.

Isolated Cretaceous area

Three miles up the river from the western edge of the Cretaceous rocks of the foot-hills, exposures were found in the bottom of the valley of shales and sandstones which appear to belong to the Cretaceous series. They are seen in the vicinity of the stream for about 300 yards, and may be more extensive, but are evidently confined to

the bottom of the valley. They probably constitute a small, isolated area, let in by faults, though it is just possible that the limestones of the mountains have been pushed eastward on a nearly horizontal thrust-plane over the Cretaceous. The evidences of enormous pressure from the westward, in this part of the moutains, would lead us to suspect the possible existence of such over-thrusts.

The eastern, or outer range of the mountains proper, is here the Fisher Range of Palliser's map. Beyond this, however, there is an outlying area of the Devonian or Devono-Carboniferous, limestone series, resembling an island in the Cretaceous foot-hills, but not much more rugged than these, nor very much exceeding them in height. The main stream of the Elbow cuts across this limestone area, and when, in 1882, Mr. McConnell followed up the Elbow for the purpose of defining the western edge of the Cretaceous rocks, he stopped at the outer or eastern edge of this area.* The northern and southern terminations of this limestone area, have not been accurately defined, but are, probably, nearly as shown on the map. Its greatest width is about four miles, and total length, probably, about fifteen miles. Outlying limestone area.

The structure of this outlying area of limestone is very simple, being that of a broad, low anticlinal, in which the base-level of the Cretaceous rises above the plane of denudation. Where crossed to the north, on the Cañon Branch of the Elbow, it shows near the west edge a subsidiary synclinal which holds a narrow trough of Cretaceous rocks. Anticlinal structure.

For four miles beyond the point at which the Elbow crosses the eastern edge of the main limestone area of the mountains, it flows nearly due north in a wide valley with extensive gravelly flats. Near the point at which it again turns eastward and strikes into the outlying limestone area, it receives the Fisher Branch from the north. This stream is about equal in volume to that followed, and comes from the west of the outer ridge of the Fisher Range, which is here remarkably straight and rampart-like, and composed of limestones dipping south-westward at an angle of about 45°. Just below the Fisher Branch a second small stream comes in. This, when followed up, leads in about three miles to a summit with an elevation of 5,800 feet, after which a trail descends northward along another stream to a transverse valley which flows to the Cañon Branch, and after crossing a second small subsidiary summit, reaches the Cañon Branch itself. From this point, we were informed, a trail continues north-westward directly through to the Kananaskis. This trail evidently follows the Cretaceous trough intervening between the front of the Fisher Range and the outlying limestone area. On reaching the Cañon Branch, however, we Fisher Branch. Detour by Canyon Branch.

* See section No. 1, facing p. 106 C, Report of Progress, Geological Survey, 1882-84.

followed it south-eastward and then southward back to the main Elbow River, at which point the Cretaceous rocks are again found overlying the limestones of the detached area, with eastward dips. The upper part of the limestone series is here formed of black, flaggy calcareous shales. These are overlain by Cretaceous sandstones, with a similar dip, and these again by a considerable thickness of dark Cretaceous shales.

Geological features.

The valley followed, between the outlying limestone area and the Fisher Range, is characterized by Cretaceous rocks, and is probably due to the existence of a considerable band of soft dark shales, which dip at an average angle of about 50° toward that range. Between these shales and the western edge of the outlying limestone area are sandstones and conglomerates, which weather rusty, and rest with an appearance of conformity on the limestones, with a dip of about S. 50° W. $<$ 30°. The subsidiary synclinal in the outlying limestone area, previously alluded to, holds a considerable thickness of sandstones, with some shaly beds of Cretaceous age. At the east edge of this trough, the limestones are again found dipping south-westward at an angle of about 40°, but further east gradually flatten out and then bend over to a north-eastward dip. The crest of this anticlinal nearly coincides with the highest part of the rather low, rounded mountains formed by the outlying patch of limestone. Before reaching the east edge of this limestone area, the stream flows for a mile through a remarkable Cañon, in which it is bordered by vertical walls of limestone, which, in some places are several hundred feet in height, and are continued above by rough and often nearly precipitous slopes to a greater elevation. It is necessary to travel in the bed of the stream, and at high stages of the water the route would be impassable. The river here appears, in its main direction, to follow that of a system of well-marked jointage-planes, which are frequently observable, and slope at a high angle to the northward.

Devonian fossils.

The lowest beds exposed occur at the west end of the cañon, and are rather soft, earthy and flaggy limestones holding numerous Devonian fossils. Amongst these are *Chonetes deflecta* and a second species allied to *C. scitula*, an *Orthis* like *O. Vanuxemi*, with two species of *Spirifera* and numerous remains of crinoidal columns.

The Kananaskis River.

Moraines and terraces.

The Kananaskis joins the Bow River at the eastern base of the mountains, making to do so a sharp northern bend. The two rivers are distant only four miles, at the points at which they respectively cross the eastern edge of the Palæozoic rocks. The most direct route from

Morley to the Kananaskis Gap, follows up Chiniquy Creek to the lake in which it originates, skirting the southern edge of the great depression of the Bow Valley. The hilly tract intervening between Chiniquy Lake and the Bow, evidently owes its character to the morainic accumulaions of glaciers which formerly debouched from the Bow and Kananaskis valleys, and is marked by low, gravelly and bouldery hills which project through terrace-flats of later origin. In the Kananaskis Gap, well-marked terraces appear on the sides of the mountains to an elevation of about 4,700 feet.

The valley of the Kananaskis differs from those of most of the rivers in the mountains, in the fact that it crosses the general direction of the ranges obliquely. In consequence of this, it is irregular in width, being in some places rough and narrow, in others wide and bordered by extensive terrace-flats. Its general course is nearly north-and-south, though with a decided convexity westward; its length, from its junction with the Bow to the Upper Lake, is about thirty-eight miles. Owing to comparatively recent forest fires, the trail is in some places much encumbered with fallen trees, and it has lost much of its old importance as an Indian route across the mountains. About its head-waters, the regularity of the constituent ranges of the mountains is somewhat interrupted, and a remarkable tract, of more than twenty square miles in area, occurs, which is characterized by terraces and low hills, but is surrounded on almost every side by high mountains. The elevation of this relatively depressed area is about 5,500 feet. It is continuous southward with the wide valley of Elk River, and to the north-north-westward with that leading to the Spray River. The want of continuity in the ranges above alluded to is, however, not due to any abrupt break, but rather to a hiatus left between several echelon-like over-lapping ridges.

Character of the valley.

Low area of country.

Geologically, the Kananaskis presents no features requiring very detailed description. The structure of the outer part of the mountains crossed by it, is shown on the eastern end of Section No. 2, on the face of the map. The Cretaceous sandstones and sandy shales, met with at the immediate eastern base of the mountains, dip S. 65° W. at angles of 30° to 45°, while the adjacent eastern outcrops of the limestones dip in the same direction at an angle of about 40°. This repeats the usual arrangement met with at the eastern junction of the Cretaceous and Palæozoic rocks, and is represented on the section as an inversion of the strata by folding, though it is possibly here brought about by faulting. From their eastern edge, the limestones, rising into high mountains, border the river for nearly eight miles; the dips being apparently all westward, and often at angles as high as 60°. The southern extension of the Cascade Cretaceous trough, which runs

Rocks near Kananaskis Gap.

Cretaceous rocks with coal.

across from the Bow, is then met with, forming a region of lower hills, and bounded to the west by high and rugged mountains attached to Wind Mountain.

It was intended to revisit and closely examine the Cretaceous rocks here, but this was not accomplished. The exposures of the rocks near the river are few, the valley being wide and trough-like. The Cretaceous rocks appear, however, to cross the valley obliquely and to terminate to the southward in the manner shown on the map. That their coal-bearing character, as developed on the Bow, continues, is evidenced by the occurrence of fragments of anthracite in the streams.

Kananaskis and Opal Ranges.

To the south-west of the Cretaceous area, the river occupies a valley bounded by the Kananaskis Range on the west and the Opal Mountains on the east. The rocks of both ranges dip westward, the former at angles of 30° to 40°, the latter at 70° to 80°, increasing southward, and in the vicinity of Tomb-stone Mountain becoming absolutely vertical and forming a very steep, rough-edged range. Both ranges appear to be composed chiefly of limestone, but the westward slopes of the Opal Mountains show a considerable thickness of brown-weathering quartzites, and these, or beds precisely resembling them from a distance, occur at the summit of the Kananaskis Range; giving reason for the belief that a fault, with eastward down-throw, runs along the valley separating the ranges. The throw of the fault must be at least equal to the height of the scarped eastern front of the Kananaskis, or about 4,000 feet.

Nearly on the horizon of the quartzites, but in limestones, on the west slope of the Opal Mountains, some fossils were found. The limestones at this place are much fractured and jointed and often weather to brown or reddish colors. Small cavities, lined with quartz crystals, occur both in these and the adjacent quartzites, and jointage surfaces are found, coated with films of opal, which, however, seldom shows the least play of colour. In one fragment of quartzite some obscurely preserved shells appeared, in which the original calcareous matter had

Fossils.

been completely replaced by amber-coloured opal. The fossils mentioned are scarcely determinable, but represent a species of *Prcductus* and a *Strophomena* or *Strophodonta*, possibly Devonian. The nearly isolated mountain forming the northern end of the Opal Range is capped by dark crumbling beds which may possibly represent a Cretaceous outlier, and in the southern part of that portion of the valley between this and the Kananaskis Range, Cretaceous shales definitely occur, forming—as far as I have been able to ascertain—the extreme northern end of the Elk River Cretaceous trough.

It is probable that a considerable part of the low area about the head-waters of the river, previously mentioned, is underlain by Creta-

ceous rocks, but it is deeply covered by drift deposits and the outline given on the map is in consequence largely hypothetical. These rocks may even be continuous or nearly so with those, of which the existence is suspected in the valley between the Kananaskis and Spray Mountains, but this valley has not yet been examined. The actual mean surface of the country, in this part of the region, is nearly on the plane of junction of the limestones and Cretaceous rocks and it is, therefore, by no means improbable that a number of small Cretaceous infolds, the existence of which was not observed, may yet be proved. Probable limit of Cretaceous.

The Kananaskis Valley, just described, forms the eastern part of the pass of the same name, but from this point we turned southward, following the Elk River Cretaceous trough. A general description of the western portion of the pass, by Captain Palliser, may be found in his report (p. 94 *et seq.*) He describes the trail as rough, and even at the date of his journey, as being much encumbered by windfall. He also mentions having observed the appearance of clay-slates, replacing the limestones of the mountains, about half-way down the Palliser River, and it is probable that a somewhat extensive area of Cambrian rocks exists there. The height of the summit of the Kananaskis Pass, given on the map as 6,200 feet, is deduced from that observed by Captain Palliser, by adding the ascent recorded by him from the prairie east of the summit to the now more correctly ascertained height of the same prairie, and is probably nearly exact. The height on Palliser's map is stated as 5,700 feet. Western part of Kananaskis Pass.

Upper Part of the Elk River Valley.

The southern branch of the Kananaskis, and the Elk River, flow in opposite directions, from an open, swampy tract, which occupies a common wide valley. This valley has a nearly north-and-south course, and is one of the larger longitudinal valleys of the mountains. The height of the watershed at this point is 6,500 feet. Watershed.

The information gained respecting the upper part of the Elk Valley was obtained in 1884 by a journey made from the summit just referred to, southward to latitude 49° 49′, a distance of forty-seven miles. At the point last mentioned, we turned eastward by the North Fork Pass, leaving unexamined a length of about twenty-eight miles, to the north of Coal Creek. The traverse was made under unfavorable conditions, owing to bad weather and the great quantities of fallen timber which occur in many parts of this valley. We were obliged to cross to the west side of the river, by a swift and deep ford, and subsequently found much difficulty in recrossing to the east side, the river having become Difficulty of traversing the Elk Valley.

very high, owing to continued rains. An unsuccessful attempt was made at rafting, after which we were obliged to spend a couple of days in constructing a canvass canoe, by which we eventually made the traverse, near the mouth of the Fording River. These circumstances are here mentioned, in order to account for the rather disconnected character of the following notes.

Northern part of valley.

For twelve miles from the summit, the valley runs south-south-east, with an average width of about two miles, and makes a total gradual descent, in that distance, of about 1,000 feet. It is partly wooded, with patches of prairie, a few acres in extent, here and there, and is often swampy. The Elk mountains, about 9,000 feet high, form a continuous wall-like range on the left, and are composed of limestones and quartzites nearly on edge. From the limestone, *Spirifera Rockymontana* and a *Terebratula*, were obtained, the beds being apparently referable to the Carboniferous. The mountains on the right, are of about the same height, but much more broken in outline. Nearly opposite the summit, a tributary stream enters the valley from the west, which is larger than that occupying the main valley, and is reported by Indians to rise in a lake or lakes south of Mount Fox. It runs, for some distance, parallel to the stream followed by the trail and joins it about three and a half miles south of the summit. Five miles further on, a second large tributary enters from the same side, and the Elk becomes a considerable river, running with a very swift current, and milky from glacier-water derived from these western streams. The tributaries from the Elk Mountains are insignificant.

Termination of Elk Mountains.

The Elk mountains gradually decrease in height southward, and at the point previously mentioned, appear to terminate rather abruptly, a low, Cretaceous ridge, intervening between their southern end and the river. At the south end of this range, a torrent, twenty feet wide by one foot deep, comes in from the east. It is this stream which, it is suspected, may head east of the Elk Mountains in the Cretaceous hills adjacent to the Highwood (p. 97 B).

Elk Valley to mouth of Fording River.

From this point, the Elk flows directly south for over forty miles, following near the western edge of an important Cretaceous trough, the width of which increases suddenly from about two miles opposite the south end of the Elk Mountains to six miles or more; the newer rocks spreading eastward to the base of the High Rock Range beyond the end of the Elk Mountains. The river-valley is never less than two, and is in some places, three or four miles in width, with a flat bottom, which has been generally densely wooded with trees of good size; but these have in large part been destroyed by fire. The mountains on the west side continue high and rugged, and are chiefly composed of limestone, with westward dips at rather low

angles. Ten miles south of the termination of the Elk Mountains, a third important tributary falls in from the north-west, and the long, low mountain ridge, in the angle between this and the main stream, shows brown-weathering beds, with a similar dip, overlying the limestones. These are, with little doubt, quartzites of the kind previously described. To the east of the river is a region of broken Cretaceous hills and ridges, generally wooded, which intercept the view of the High Rock Range.

Finding the main valley almost impassable from fallen timber and swampy ground, we climbed the Cretaceous ridge nearly opposite the mouth of the tributary just alluded to, and after following it for some miles, descended easward to the head-waters of the Fording River. This stream flows southward, parallel to the Elk, and in the same great Cretaceous trough, for over twenty-five miles,—nearly midway between it and the base of the High Rock Range, but separated from it by the Green Hills and continuing ridges. Fording River.

Occasional fragments of coal were observed on the gravel bars of the Elk above this point, but on reaching the upper part of the Fording River, so much drift coal was found in it, that half a day was devoted to tracing it up to the seams from which it was derived. The position of these is marked on the map. There are several thin seams at this place, the thickest observed being about two feet, but the exposures are not very good or extensive. The coal is bituminous and apparently of good quality, and occurs in association with shales and sandstones of the usual character. In these, a few fragments of fossil plants were ound, resembling those elsewhere obtained in the Kootanie group, and including specimens of *Pinus Suskwaensis*. The dip is eastward at low angles; but it appears, from views of the High Rock Range, afterwards obtained, that the Cretaceous beds take a reverse inclination farther east, dipping westward from the flanks of these mountains. Coal seams.

After following the Fording River south-westward for a few miles, we crossed the Green Hills by a sort of pass, and again reached the Elk. The summit has an elevation of 6,226 feet, the hills above the notch by which it is crossed being several hundred feet higher. From this point, a very extensive view was gained both to the east and west, as well as down the Elk Valley. The country between the Green Hills and the High Rock Range is a mass of steep, Cretaceous hills, which reach an altitude, in some cases, of 7,000 feet or more, and are often bare and treeless about the summits and upper slopes. Where rocks come to the surface, they generally weather to reddish tints, and are easily distinguished from the more distant grey limestone peaks of the main range, of which they form foot-hills. The limestone ridge constituting the High Rock Range, is here narrow, but attains a height of at least Green Hills and High Rock Range.

8,000 feet, and is marked by some conspicuous, bold peaks, one of which was recognized as having been seen in 1883, from the head-waters of the North-west Branch of the Old Man.

Mountains west of the Elk. To the west, the range on the opposite side of the Elk is evidently almost entirely of limestone, which in places is nearly flat, but more generally has a low, westward dip. The front of the range here presents a series of rugged cliffs, broken at intervals by wild gorges, and is very high. Beyond it, however, the summits of a second and still higher and more rugged tier of mountains are seen, and in this, most of the streams flowing to the Elk head. It is probable that some of the highest peaks in this part of the Rocky Mountains will be found in this unexplored region west of the Elk River.

The Green Hills, where traversed, were found to consist of Cretaceous rocks with the usual characters, and with eastward dip, at angles of 20° to 40°. On the scarped, western side, not far from the summit, a coal-seam several feet in thickness was observed, but so much weathered and covered with rubbish that its precise importance could not be ascertained.

Greatest width of Cretaceous. This northern portion of the Elk River Cretaceous trough attains its greatest width—about ten and a half miles—precisely on the 50th parallel. At the same point, the Wī-suk-ī-tshak Range appears as a limestone ridge in the centre of the trough, and contrasts strikingly in its rough outlines and bare, rocky cliffs and slopes with the more rounded and generally wooded Cretaceous hills.

Elk River south of Fording River. About seven miles north of the 50th parallel, the Fording River eventually joins the Elk, and here we left the Elk Valley, turning east by the North Fork Pass, previously described (p. 82 B). Several important streams reach the Elk from the west, within a few miles of this place, and up one of them, a trail is reported to run, which reaches the Kootanie east of Mount Sabine. A few miles south of the same point, the Elk turns more to the westward, and it must pursue a general course of about south-south-west to the mouth of Coal Creek, where the Crow Nest Pass reaches it. This part of the valley was reported to be at least as much encumbered with fallen timber as that which we had traversed.

Trees. *Larix Lyallii* occurs as a straggling growth near the summit between the Kananaskis and the Elk. Further down the river, some fine groves of *Picea Engelmanni*, *Pinus Murrayana* and *Abies subalpina* were observed, and these trees constitute the greater part of the forest. The first Douglas fir noticed in the valley was at a point five miles south of the end of the Elk Mountains. Specimens of *Larix occidentalis*, of fair growth, first occur near the mouth of the Fording River, and the juniper was here observed to become arboreal in habit. The cedar

is reported to appear about five miles further south in the valley. It is abundant and large, as already mentioned, at the point at which the Crow Nest trail enters the valley. Birch trees of medium size were seen in the defile by which the Wi-suk-i-tshak Range is crossed, together with the little mountain maple (*Acer glabrum*). *Pinus albicaulis* occurs on the summits of the Green Hills, and probably elsewhere, at similar elevations. Notwithstanding the great areas destroyed by fire, there is still in the aggregate a large amount of fine timber in this valley, some spruce groves showing numerous trees which attain a diameter of three feet. The importance of this timber lies in the fact that the river affords a means of running it down to the Kootanie Valley. **Timber.**

The snow-fall in winter must be exceptionally heavy in the upper part of the Elk Valley. Evidence of a great depth of snow is afforded by the height at which branches have been broken by it, and the green, treeless beds of snow-slides appear on the mountains both to the east and west at innumerable points. **Snow-fall**

As will have been gathered from the foregoing description, the northern part of the Elk receives by far the greater portion of its water from the mountain region to the west of the valley.

The main facts in connection with the appearance and outlines of this part of the Elk River Cretaceous trough, having been given above it need only be added, that disregarding minor irregularities, of which, there are many, its structure appears to be synclinal, the axis of the syncline lying (between the Elk Mountains and the 50th parallel) to the east of the river. South of this point it becomes separated by the Wi-suk-i-tshak Range into two parts, which probably also have synclinal structures. The western edge of the trough is, however, probably defined throughout by a great fault or series of great faults, with eastern downthrow. No exact evidence of such faulting was gained, but none of the appearances elsewhere characteristic in the mountains, of overturned folding, were observed. Between the latitude of the Fording River and the Crow Nest Pass, the outlines given to the Cretaceous area are almost entirely hypothetical, and it may be regarded as quite probable that northward-running spurs extend into the mountains west of the Elk in this part of its course. A small Cretaceous outlier appears to occur high up in the limestone range to the west of the Elk, opposite the Green Hills, as indicated on the map. **Elk River Cretaceous trough.**

White Man's Pass and Sinclair Pass.

East entrance to pass.

Opposite Canmore station, on the Canadian Pacific railway in the Bow Valley, the entrance to the White Man's Pass (so-called by the Stoney Indians) appears as a remarkable notch in the front of the massive range which runs south-east from Mount Rundle. A mile and three-quarters from the Bow River, the base of the range is reached, and thence a rapid ascent is made of about 1,000 feet, the trail following the right bank of a little torrent, near which, about half-way up the ascent, a cave occurs.* The summit level is reached at a height of 5,300 feet, and here the valley followed by the trail becomes a narrow V-shaped defile, the bottom of which is encumbered with rocky *debris* from the impending mountains. The stream just referred to, flows out from beneath the loose material a short distance below the summit. On passing through the defile, the trail reaches a little flat meadow at its western embouchure, without making any appreciable descent, and joins the wide, longitudinal valley between the range just crossed and the Goat Range.

Valley between Goat and Rundle mountains.

The south-west side of Mount Rundle range, forming the back of the Three Sisters, and other peaks seen from the Bow, is largely composed of bare surfaces of limestone, dipping nearly at the angle of the slope, while the opposite front of the Goat Range repeats the precipitous and rough appearance of the corresponding aspect of the first-mentioned range. The longitudinal valley between them runs south-eastward for six and a half miles, and then south-south-west for six miles, there inosculating with that of the Spray River, at an elevation of about 5,260 feet. A short distance south from the opening of the defile, a watershed occurs in the valley, one small stream flowing in the direction just indicated, to the Spray, the other going north-westward and joining the same river after it enters this valley, by passing between the Goat Range and Terrace Mountains. The height of the watershed scarcely differs from that of the defile, and the valley throughout is rather wide and flat-bottomed, and filled more or less deeply with detrital materials. It is highly probable that the Spray, or some former representative of that stream, at one time flowed through this now abandoned valley from end to end.

Very high mountains.

Six miles south-east from the defile, the trail leaves the valley for some distance, and crosses a spur of the Goat Mountains, descending again to the border of Trout Lake, about two miles in length, which

* Of this cave the Indians tell some curious stories, but it is not extensive according to Mr. D. McDougall, who has examined it.

lies transversely to the general trend of the mountain axis, between the ends of the Goat and Kananaskis Ranges. From a point near the east end of the lake, a trail is said to run across the mountains to the Kananaskis River. The most prominent summit on the north side of the lake has an altitude of nearly 10,000 feet, while the highest peak to the south, surpasses 9,000 feet, and Wind Mountain, and another near it, attain 10,100 and 10,400 feet respectively, the whole combining to form a very rugged landscape, the higher parts of the mountains being nearly everywhere almost absolutely bare rock. In the longitudinal part of the valley, morainic ridges, more or less degraded, are abundant, and the lake is held in, either by material of similar origin, or by *débris* washed down from the mountains, there being no appearance of a rock-basin. The position of the part of the valley occupied by the lake is remarkable, as it cuts completely across what would otherwise be a continuous, high, limestone range. The whole valley, from the defile to the Spray River, has originally been well wooded, but most of the timber has been destroyed by fire, the fallen trees rendering the trail rough and difficult. In the longitudinal part of the valley, some patches of timber still remain unburnt. On the north side of the lake it has been completely destroyed, but on the slopes to the south, only about half has been burnt. **Trout Lake.**

Geological features. The geological features of the Bow Valley, near the entrance to the pass, are elsewhere described. The Mount Rundle range is formed of an anticlinal of limestone rocks, completely overturned to the north-eastward, as shown in figure 6 (p. 127 B). On the side of the range furthest from the Bow, these dip to the south-westward, at angles of 40° to 45°. The limestone rocks of the north-east side of the Goat Range, dip in the same direction, but at somewhat lower angles. On the south-west side of the same range, the dips become much higher, averaging nearly 60°. The attitude of the rocks, in this part of the pass, is shown in a general way on the eastern end of Section No. 2, but it is uncertain whether the Goat Range forms a second overturned anticlinal, or is separated from the first range by an extensive, longitudinal fault.

Carboniferous fossils. At the point above referred to, at which the trail passes over a spur of the Goat Range, a few fossils, which are referable to the Carboniferous were obtained in beds of hard grey, and reddish-grey, calcareous sandstone associated with the limestones. These include the pygidium of a *Proetus*, *Athyris subtilita* (?), a second form, allied to the same species, and a coral probably referable to the genus *Zaphrentis*.

Wide longitudinal valley. From Trout Lake westward to the Kootanie, the White Man's Pass runs nearly at right angles to the general trend of the mountains. At the point at which the stream from the lake reaches the Spray, the river makes a right-angled bend, and flows northward in the longi-

tudinal valley to the west of the Goat Range. This valley is continued southward between the Kananaskis and Spray Mountains, and carries a small tributary to the Spray, which must rise near the source of one of the branches of the Kananaskis River. A trail is also reported to run up the valley to the Kananaskis. The northern part of this longitudinal valley, is a wide, straight, flat-bottomed depression, of the usual type. Its continuation to the southward is, however, nearly twice as wide, exclusive of an area of hills and ridges, which occupy a part of the low area, and attach westward to the Spray Mountains.

Fall. A mile and a half above the point at which the Spray turns northward, it forms a picturesque fall, about forty feet in height, over pale-grey limestone rocks. The trail, then following the north-bank of the river, through green woods, passes between the north end of the Spray Mountains and Cone Mountain,—the latter, a sharp, symmetrical peak, composed of vertical beds of limestone, with a conspicuous, oblique fissure on the south side. West of Cone Mountain, a tributary about equal in volume to the main stream, joins from the north. A well-marked trail runs up its valley, and is reported to join the Simpson Pass, east of the main watershed. From this point the main stream turns southward, occupying another longitudinal valley to the west of the Spray Mountains, up which a second Indian trail to the Kananaskis runs. About four miles to the south, the Spray Mountains culminate in a remarkable, pyramidal peak.

Spray Mountains and Cone Mountain.

The Blue Mountains. Turning southward from the mouth of the tributary, just mentioned, the trail is at first rough, passing over a surface of limestone rocks; it then traverses prairie patches and open woods, passes the entrance of a deep and picturesque valley, in the Blue Mountains—here the watershed range—and reaches the base of the same range at the mouth of a second valley of the same character. This carries a small tributary stream, in following which a pretty steep ascent is first made to a deep, narrow valley, with sub-alpine vegetation and occasional open meadows. The stream enters the head of this valley from the southward, coming from a gorge which separates the high, bare outer ridge of the range from the summit elevations. From the bank of the stream, a rapid ascent is made, by a series of steep zig-zags, near the small torrent, which dashes down over limestone rocks, and the actual summit reached, at an elevation of 6,807 feet. The summit is here found in a wide, irregular, open valley, which supports a scattered growth of stunted and wind-lashed trees. A small lake feeds the torrent just mentioned.

Limestone series. The rocks seen along the part of the pass just described, are all referable to the great limestone series, and in Cone Mountain and the Spray Mountains, are almost absolutely vertical, and may be considered as forming a continuation of the similarly characterized western ridge

of the Saw-back Range to the north. It is not improbable, however, that the valleys to the east and west of the Spray Mountains may hold infolds of Cretaceous rocks, as previously indicated in connection with the Kananaskis (p. 107 B). The culminating peak of the Spray Mountains shows a high spur on its west side, between which and the apex, is seen a narrow fold of vertical, dark-coloured rocks, which are almost certainly Cretaceous. At the eastern base of the Blue Mountains, the limestones appear to dip south-westward, but further up toward the summit, have a general tendency to dip to the north-east, though often wildly contorted and exhibiting a series of large, parallel corrugations. The actual summit appears to coincide with a well-marked anticlinal axis, which runs with the range. On the east side, the limestones are nearly vertical, but turn over and dip at low angles south-westward on the opposite slope. Some red beds appear near the summit, which may possibly represent the Triassic rocks seen further southward.

Cretaceous rocks.

Rocks at the summit.

From the summit, the Cross River is followed down to the Kootanie. This stream is called Tsha-kooap-tē-ha-wap-ta, by the Stoneys, and its name alludes to the circumstance related by them that some early traveller set up a cross in the pass, not far from the summit.* From the summit, the stream descends very rapidly to the south-westward, in a narrow rocky valley, shut in by high and rough mountains, falling about 2,300 feet to the mouth of North Creek, at which point its elevation is 4,471 feet. North Creek and other tributaries received in this part of its course have the character of mountain torrents. Half-way between the summit and North Creek, a high, rocky valley opens southward, which towards its head holds masses of glacier-ice, and shows a number of small cascades. After breaking through the next range to the westward, the Cross River flows northward for a couple of miles, in a narrow, wooded, longitudinal valley, and before again turning west, joins a stream of about equal size,—the North Fork,—derived from the northern and wider continuation of the same valley. To this point the descent of the river continues very steep, and it shows numerous little cascades and rapids, the clear blue water having carved its bed in white marble. It next flows westward for about seven miles, in a wide and flat valley, characterized by extensive gravel bars and numerous sloughs and flood-channels, and precisely resembling the corresponding portions of the Kicking Horse and Vermilion valleys. Before reaching the Kootanie, it again

Descent westward.

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* Since the above was written, I have had an opportunity of referring to De Smet's *Oregon Missions* (New York. 1847). De Smet in his Missionary Journey of 1845 evidently traversed what is now named the Sinclair Pass. He subsequently mentions the "Vermilion River," as on the approach to the watershed, but this name is probably not applied to the same stream now so-called. He describes the erection of a cross at the point at which he traversed the watershed (p. 144), and this fact, taken in connection with the Indian tradition above referred to, and the context of his narrative, render it almost certain that he crossed to the Bow River by the White Man's Pass.

changes its direction to southward, flowing past the long, sloping, wooded end of the Mitchell Range. The trail there leaves the river, cutting across a spur and reaching a ford of the Kootanie at an elevation of 3,440 feet.

Rocks on west slope.

From the immediate vicinity of the summit of the pass, westward to the mouth of the North Fork, the limestones, both in the bottom of the valley and so far as could be observed, to the tops of the adjacent mountains, have become changed to marble, which is in some places very coarsely crystalline. In colour, the marble generally varies from white to yellowish shades, but blotched grey and white, and brown and white varieties were also observed. More or less pyrites and grains of magnetite are generally disseminated through the rock, and in all the streams a great abundance of crystalline vein-matter, calcareous, dolomitic, or silicious, was noticed. Though no metalliferous minerals of value were observed, this appears to be a locality worthy of the attention of the prospector, on account of the extent and character of the local metamorphism. In no other place in the mountains were the limestones observed to be altered over so extensive an area. The cause of the alteration is obscure. It is accompanied by no evidences of special mechanical violence, as the beds west of the summit dip southwestward at low, regular angles, nearly equalling that of the slope of the valley, and further down, becomes nearly horizontal, or show very light north-easterly dips. There is reason to believe, however, that an intrusive mass, resembling that subsequently described, (See also p. 122 B) may here nearly approach the surface, though it has not actually been exposed by denudation.

Marble.

Vein matter.

Cause of alteration of rocks.

Rocks west of North Fork.

In about four miles below the mouth of the North Fork, the wide valley cuts through two mountain ridges, which together show a general synclinal structure. At the western edge of this syncline, however, a a narrow anticlinal, bodily overturned to the eastward, was observed far up in the mountain range, opposite the mouth of the North Fork. The rocks of this part of the valley seem to belong, chiefly, or entirely, to the limestone series, though their broken and jointed character rendered it difficult to distinguish the nature of the beds in the mountain sides.

Diorite.

At the mouth of the second tributary below the North Fork, on the same side, are numerous large masses of greenish-grey diorite (?), somewhat resembling the intrusion of Ice River (p. 122 B) but apparently not, like that, a nepheline-syenite. These have been derived from an intrusion of the same material, against which the limestones rise to an angle of 45°, and form the steep, western edge of the synclinal just mentioned. The area of the intrusive mass may be extensive to the north of the valley of the pass. Associated with, and cutting the diorite, are quartz veins, carrying copper pyrites, but on assay by Mr. Hoffmann, these proved to contain neither gold nor silver. The vicinity

of this intrusive mass, however, is one to which the prospector might devote attention with some probability of good results.

Beyond the stream near which this intrusion occurs, the main valley becomes floored by slaty rocks, which vary from nearly black to grey in colour, and are generally glossy and usually rather soft. The bedded structure has been almost entirely obscured by cleavage, but the slates are often more or less calcareous, and from the appearance here and also at some places near the bases of the mountains further up the valley, there is reason to suspect a passage of these into the overlying limestones, with possible conformity. The circumstances in this connection repeat those elsewhere noticed on the Kicking Horse, and the rocks are very similar in appearance. Cambrian rocks

The spur forming the termination of the Mitchell Range is again composed of the usual grey massive limestone.

The Sinclair Pass forms a direct western continuation of the White Man's Pass, and affords a cross section of the western range of the Rocky Mountains, which appears under the name of the Brisco Range to the north, and the Stanford Range to the south. The Upper Kootanie Valley has been mentioned in the introductory part of this report as one of the most important in the mountain region. It is here about three miles in width between the slopes of the adjacent mountains. Its surface is formed chiefly of terrace accumulations, and is generally wooded, scarped banks here and there along the river showing white silts with interbedded gravels like those elsewhere described (p. 30 B). The ford is a good one at low water, but it would be impassable when the river is in flood. Upper Kootanie Valley.

The range crossed by the Sinclair Pass has a width of about nine miles only. The valley traversed by the pass is not structurally a very important one, being rather narrow, particularly about the summit. The trail is rough, crooked, and in places very stony, following in some places the bottom of the valley, in others climbing far up the steep slopes. On the east side, the timber has not been extensively destroyed by fire, but it is nearly all burnt on the western slope in the valley of Berland's Creek. The range crossed, is found to consist of at least, three subsidiary mountain ridges, but the intervening valleys are narrow and not very definitely continuous. The summit, with an elevation of 4,662 feet, is reached at three miles from the eastern base, and Berland's Creek, flowing westward, heads in a pool or small lake, which is evidently held in by an accumulation of *débris* washed into the valley from the adjacent mountains. Where it cuts through the western mountain ridge, the stream flows for over a mile and a half in a very deep, narrow gorge, after leaving which, it cuts for itself a wider, but still deep valley in the high gravelly and silty terraces of the Sinclair Pass. Berland's Creek.

Columbia Valley. The cedar grows in the pass from the summit to the western base of the range. The birch and shrubby maple (*Acer glabrum*) characterize the pass throughout, together with the Douglas fir, Engelmann's and the balsam spruce and the black pine. *Fatsia horrida* is found about the summit.

Vegetation.

Rocks on Sinclair Pass.

The Cambrian rocks, which are supposed to underlie the flat valley of the Kootanie, were not seen on this traverse, and the rocks of the mountains between the Upper Kootanie and the Columbia, appear to be all referable to the limestone series. These, in the eastern ridge of the mountains, form an anticlinal, but westward, are almost everywhere on edge. Near the middle of the gorge, the cliffs assume a bright red colour, and from the Columbia Valley, the same red zone may be traced for several miles along the front of the mountains, apparently nearly following the strike of the vertical rocks. On examination, the red rock is found to be in general completely shattered, and generally more or less porous and cavernous, though re-cemented by calcareous matter. This shattered zone appears to have formed a conduit for mineral waters, which may possibly have been thermal and the coloration has been produced, either by the deposition of iron by these waters, or by the peroxidation of ferruginous minerals already present. Sir George Simpson's description of this pass has already been referred to (p. 10 B).

Reddened limestones.

Simpson Pass.

This, as previously stated (p. 9 B), is the pass followed by Sir George Simpson to the Upper Kootanie Valley in 1841. By the Stoney Indians it is known as the Shuswap Pass. It leaves the Bow River at a height of about 4,500 feet opposite Hole-in-the-wall Mountain, to the west of Bourgeau Mountain, and follows Heely's Creek to its source, crossing the watershed at a height of about 6,650 feet, at a distance by the valley of nearly nine miles from the mouth of the creek. The head waters of Simpson River are here found to the east of the range which, further north, constitutes the summit ridge. The descent on the the west side is steep, amounting to about 1,900 feet in five miles. About eight miles further on, the trail joins that of the Vermilion Pass at the confluence of the Simpson with the Vermilion River, at a height of 3,932 feet. This pass was examined by Mr. R. G. McConnell in 1885.

The Vermilion Pass.

Pass in the Bow Range.

Like the White Man's Pass, Simpson's and Kicking Horse passes, the eastern approach to this route over the watershed is formed by the great valley of the Bow. The trail leaves the Bow opposite Silver City, at an elevation of 4,624 feet, and reaches the summit by following Little

Vermilion Creek to its head, in a distance of six and a half miles, the summit elevation being 5,264 feet. From the summit, the valley of the pass continues exactly transverse to the Bow Range for six miles, when it joins one of the more important longitudinal valleys of the mountains, and bends through a right angle to a south-eastward course. The height of the river at this bend is 4,523 feet. As pointed out by Dr. Hector, who first examined this pass, it is exceptional in the near equality of its grades on both slopes.

Summit lakes.

The north-eastern front of the Bow Range is abrupt and wall-like, the pass entering it by a deep notch, in the eastern opening of which is a little lake about half a mile in length. This is connected by a stream, with a still smaller pool, which practically occupies the summit, though the ground rises slightly for a short distance beyond its head. Less than half a mile further on, a milk-white torrent, forming the source of the Vermilion River, and fed by masses of glacier ice in the southern end of the Bow Range, enters the pass. The valley, however, continues to be narrow, and in general, densely wooded as far as the bend.

Rocks of Bow Range.

The north-eastern escarpment of the Bow Range, at the entrance of the pass, appears to be entirely composed of quartzites and slaty rocks, referable to the Cambrian, with persistent, light, south-westward dips, at angles of 20° to 30°. Shortly after entering the pass, however, the overlying limestone series appears, forming the summits of the mountains; and owing to the dip, gradually descends in their slopes, till it reaches the bottom of the valley about three and a half miles westward. It is shortly, however, again replaced in the mountains near the bend, by the slaty and schistose rocks, which dip south-westward, at an angle of about 40°. The mode of junction of the limestones with these rocks, on the west side, was not here observed. The total thickness of quartzites and slaty rocks, referred to the Cambrian, exposed in the north-east side of the Bow Range must approach 5,000 feet. The rocks exposed near the second little lake, at the summit, are probably about 2,000 feet below the base of the limestone series, and in these, on the 6th of August, 1884, the first fossils found by us in place in the rocks of this series were obtained. These consisted of two rather obscure impressions of trilobites, one of which has, however, been definitely recognized by Prof. C. D. Walcott as *Olenellus Gilberti.* Careful search failed to bring to light any other forms in this place, but annelide burrows abound, both vertical and horizontal, (often filled with quartzite in the case of the schistose rocks,) together with various more or less obscure tracks and markings. The rocks themselves are here whitish, grey and pinkish quartzites, in which broken fragments of red shale are frequently imbedded as pebbles, as previously noted on the South Kootanie Pass. With these are interbedded grey and blackish, schistose argillites, which are not cleared.

Cambrian.

First Cambrian fossils.

Chalybeate springs.

The Vermilion Pass takes its name from the existence of considerable deposits of ochre on the river-flats, about six miles west of the summit, near the place previously alluded to as the bend. These are produced by very copious chalybeate springs, which flow out in the gravel, and may some day be utilized medicinally. The ochre is naturally yellow, but the Indians cause it to assume a red colour by burning it.

Near the bend, a couple of large streams enter from the mountains to the westward, and the river more than doubles its former size. The valley of one these streams appears to correspond with the longitudinal valley occupied by the Otter-tail farther north, with which it is, very probably, continuous.

Vermilion River valley.

From this point the Vermilion flows south-westward, fifteen miles, in a valley which at first averages about a mile in width, but becomes much wider where it is joined by the Simpson River. This portion of the valley presents no features of particular interest. The Vermilion Range, to the south-west, has a synclinal structure; the axial summits, which reach elevations of about 9,000 feet, are nearly three miles back from the valley, the intervening space being occupied by buttress-like spurs, attaching to the central mountains, but separated from each other by a number of deep, rough narrow valleys. These spurs appear to be entirely referable to the Cambrian series, and to consist chiefly of schistose or slaty rocks, with persistent, south-westward dips, at an angle of about 30°. The axial mountains are evidently of limestone. On the opposite side of the valley, the bordering mountains are more rounded in form, and glimpses can only occasionally be caught of higher and rugged peaks further back, toward the watershed range. The river for a number of miles nearly follows the strike of a band of yellowish-gray, glossy slates and schists, which often hold little nodules of pyrites, and resemble those seen near Boulder Creek on the Kicking Horse. Grey and black, distinctly argillaceous and often, calcareous slates, also occur, in which the cleavage cuts the bedding at a high angle. The cleavage-strike at one place was observed to be N. 65° W., with dip at an angle of 45° southward. Large pebbles of diorite or nepheline-syenite, in the river, appear to indicate, either that the intrusion of rocks of this character, seen on Ice River (p, 122 B), extends to some of the sources of the Vermilion, or that another similar intrusion occurs within its drainage area.

Cambrian slates.

Pass in Vermilion Range.

Turning westward again at a right angle, from the mouth of Simpson River, the Vermilion cuts through the mountains, which separate it from the upper part of the Kootanie, and, in about seven miles, joins that river at an approximate elevation of 3,800 feet. The river runs for part of this distance in a narrow gorge, while the trail, following the

hill-side to the north, is very rough and bad. On approaching the limestone which forms the central mountains of the Vermilion Range, the slaty rocks become bluish in colour, and occasionally hold beds of hard, blackish-blue limestone, giving rise to the same appearance of a passage between the series, as occurs near the mouth of the Beaver-foot. On the north-east side of the synclinal, the limestones dip at first at angles of 40° to 45°, but westward, become in this place nearly vertical. The axial mountains, on both sides of the gorge, are very steep and bold.

The forest in the Vermilion Valley has been comparatively little destroyed by fire, and there are some areas of timber of very fair quality, both on the slopes of the mountain and to the north-east of the valley above the mouth of Simpson River, and in the narrower part of the valley below that river. **Timber.**

The Vermilion River is nearly twice the volume of the Kootanie at their point of junction, and might, in consequence, be regarded as entitled to bear the latter name; but the circumstance that the Kootanie occupies the larger and more continuous valley, induced Dr. Hector to name these streams as they now appear on the map. The valley of the Kootanie is continued north-westward by that of the Beaver-foot, to the angle of the Kicking Horse River, and between the Vermilion and Brisco Ranges, has an average width of nearly four miles, resembling—though on a somewhat smaller scale—that of the parallel portion of the Columbia. Up to the summit between the Kootanie and Beaver-foot, the valley is generally wooded, and contains some good timber, though with occasional open meadows and little prairies. The water of the Kootanie is clear, and the current rather swift, though much less so than the Vermilion. The river follows a tortuous course in a trough-like depression in the centre of the valley, about three-quarters of a mile in width, and bordered by gravelly terraces, which run back to the bases of the mountains on either side. The rise in the valley from the junction of the two streams to the summit above referred to, is about 338 feet, in a distance of seventeen miles, the summit elevation being 4,158 feet. The summit is swampy, and Dr. Hector describes the Kootanie as rising here in two small lakes, which, as we kept close to the base of the mountains to the east, we did not see. **Head-waters of Kootanie and Beaver-foo**

The rocks seen along the upper part of the Kootanie are rather soft, grey or yellowish, silvery slates. These or similar Cambrian rocks appear to occupy the whole width of the valley, and also to constitute all the lower hills of the Vermilion Range. The central mountains of this range are very bold and steep, reaching heights greater than 9,000 feet, and being apparently still composed for the greater part of limestone. The Brisco Range, on the opposite side of the valley, **Rocks.**

appears to be throughout this part of its length entirely of limestone, which at first has persistent low westward dips, but toward the Kootanie-Beaverfoot summit becomes in some places more disturbed and nearly vertical.

Beaver-foot River.

The Beaver-foot rises in the mountains to the north-east of the wide valley, just beyond the summit, and after flowing north-westward in the valley, twelve and a half miles, reaches the Kicking Horse at its angle. Where it enters the valley it is a swift stream, about thirty-five feet wide by six inches deep. About four miles further on it is joined by Ice River,* which is about equal in size. The part of the valley occupied by the Beaver-foot is not so wide and parallel-sided as that holding the Kootanie. The original forest has in most places been replaced by second-growth woods, including much aspen, though belts of good spruce timber still exist in places, particularly along the banks of the river. The valley is generally marshy near the river, and at the sides bordered by irregular gravelly terraces.

On approaching the Kicking Horse, the Beaver-foot Range, forming the south-west side of the valley, becomes bordered by rounded and wooded hills, composed of slaty Cambrian rocks, and rocks of the same kind underlie the valley, as far as observed.† The centre of the high range on the opposite side of the valley, however, is here formed of an important mass of intrusive syenitic rocks, which were examined on Ice River, where they are extensively developed.

Ice River.

The valley of Ice River runs northward for about seven miles into the heart of the Otter-tail Mountains, between Mounts Vaux and Goodsir, of Hector, and terminates at the base of a high narrow range which separates it from the Otter-tail Valley. It is deep and narrow, being closely hemmed in by the neighbouring mountains, while the stream itself is a mere torrent, often encumbered by masses of rocks from the rough mountain slopes. The mountains at the head of the valley are covered with glaciers, one of which shows, from a distance, a cliff of solid blue ice which is probably several hundred feet in height.

Important intrusive mass.

The intrusive mass above alluded to, is first seen on Ice River about two miles up the valley from the south-western base of the mountains at its entrance. The mountains on the east side of the valley are here composed of this syenitic rock for their whole height. Further up it

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* *Wash-ma-wap-ta* of the Stoneys.

† Dr. Hector, who followed the route here described, writes:—"In the bottom of the valley we passed several masses of true gneiss with one or two greenstone dykes." (Journals, Detailed Reports and Observations Relative to the Explorations by Captain Palliser, etc., p. 105). It is, therefore, probable that crystalline rocks like those of Ice River may occur also in some places near the Beaver-foot, but none of the rocks seen by us could be described as true gneiss.

forms the entire mass of the mountains on the opposite side of the valley, and apparently also of those at its head. Southward, the same mass continues at least as far as the head of the Beaver-foot, where it is again seen constituting the axial mountains of the range. Its termination in this direction has, however, not been defined, nor has the western edge of the mass been outlined. Its extent and character deserve further investigation, as its occurrence is correlated with the appearance of much vein matter in the neighboring rocks, and very probably with the metalliferous deposits now being prospected on the Otter-tail River.

The circumstances connected with the contact of this intrusive mass with the slaty Cambrian rocks on the Ice River, show that it is newer than these rocks, but older in date than the cleavage which has since affected them, and which is probably referable to pressure in connection with the main period of mountain upheaval. The mass may in part break through the Cambrian, but it has also forced the rocks of that formation upward, causing them to dip away from its flanks. Near the mass, these elsewhere slaty rocks lose all appearance of cleavage, and though plainly showing their original bedding, are baked and porcelainized. They are generally grey to black in colour, though in some cases nearly white, and form a hard petrosilex, which rings under the hammer. The intrusive mass itself, though very varied in appearance in different places, is, in the main, a nepheline-syenite. The form most abundantly represented is a medium- to coarse-grained crystalline rock, composed of felspar, nepheline and hornblende in varying quantities, with grains of magnetite and some crystals of sphene. The colour generally varies from pale- to dark-grey, becoming nearly black in some places, when the hornblende greatly preponderates. In such black varieties sphene is particularly abundant. The crystals of the component minerals are occasionally nearly an inch in length, while in rare instances they become almost cryptocrystalline. Other specimens derived from the same occurrence, but found as boulders in the bed of the torrent, have a banded and almost gneissic aspect, and under the microscope prove to contain numerous grains of quartz. A material of this character is probably that to which Dr. Hector has referred as gneiss, but there is no evidence of its sedimentary origin.

Junction of igneous rocks with Cambrian.

Character of intrusive mass.

As far as I was able to determine, the mass appears to have been much disturbed, and, as it were, kneaded together while in a plastic or semi-plastic state. Portions of it have become brecciated, and are re-cemented by similar material, differing only in texture or colour. Veins and crevices, which have evidently been filled by segregative action, also occur, and in these, minerals similar to those composing the main mass are developed; but with them, in considerable abundance,

Its structure.

sodalite of a beautiful ultramarine-blue colour is found. In the same veins crystals of ilmenite were observed. This mineral has been subjected by Mr. C. Hoffmann to a rough quantitative analysis, and found to contain titanium dioxide, 47·5 per cent.; iron, equal to 39·8 per cent. of ferrous oxide, with 6·5 per cent. of manganese. No other constituents were sought for, and the specimen included a small percentage of gangue. The large proportion of manganese is very remarkable.

Ilmenite.

Sodalite.

The sodalite has been analysed by Dr. B. J. Harrington, who describes it in the Transactions of the Royal Society of Canada, Vol. IV., Sect. IV. It much resembles lapis lazuli in appearance, and would have considerable value as an ornamental stone. It is not confined to a single part of the intrusive mass, as it was found also to occur in fragments brought down from the mountains further south, in the bed of the Beaver-foot, and closer search than we were able to make would probably lead to the discovery of even larger pieces than those we obtained, some of which are several inches in diameter.

Drift fragments of intrusive rocks.

Intrusive rocks are of such rare occurrence in this part of the mountains, and the appearance of those here met with is so characteristic, that detached fragments at once catch the eye. The occurrence of such fragments on the Vermilion, below the bend, has already been noted, and its significance alluded to. Small pieces of the same rock were found in the Kicking Horse above the mouth of the Beaver-foot, and apparently show that some similar intrusive mass occurs on its head-waters or those of the Otter-tail. A few well-rounded pieces of the same material were found in 1883 in the Columbia-Kootanie valley south of the lakes. It is uncertain whether these were carried to their present position by the Vermilion and Kootanie Rivers, at a former period, or by a southward movement of ice during the glacial period. The latter supposition appears the most probable, as the fragments occurred on a terrace at some height above the present stream.

Bow Valley.

Account here given merely preliminary.

The character of the portion of the Bow Valley within the mountains has already been described in general terms (p. 27 B). It is of particular interest as being the route adopted for the railway which now renders it readily accessible to every traveller. The geological features of the Bow and Kicking Horse valleys were, however, not more closely investigated than those of other parts of the extensive tract of mountains here reported on, and as Mr. R. G. McConnell is at present engaged in supplementing such reconnaissance work by a special and thorough

examination of these particular valleys, the results of which will soon be prepared for publication, it is considered unnecessary here to enter into any lengthened description of my own preliminary work. An exception is, however, made in the case of that part of the Bow Valley which includes a portion of the Cascade Cretaceous basin. This, on account of its important occurrences of anthracite, has been surveyed in detail, and is here treated at some length and illustrated in the accompanying special map. With this exception the following notes must be considered as of a strictly preliminary character.

Bow Valley in foot-hills.

To the east of the mountains the Bow River flows in a great valley, from four to five miles in width, which crosses the general direction of foot-hills exactly at right angles. The general appearance of this valley near the base of the mountains is illustrated in a previous report.* For a width of twenty miles east of the base of the mountains, the Cretaceous rocks are here thrown into a series of parallel and often compressed plications, the intricacies of which yet remain to be worked out, and the rocks are often for considerable distances nearly vertical. At the base of the mountains, however, these beds are found to lie at comparatively low angles, and to show a nearly uniform dip toward the outer limestone range, beneath the rocks of which they appear to pass in consequence of the existence of an overturned anticlinal fold, which is possibly also accompanied by faulting.

Lower part of valley in mountains.

The limestone of the mountains, though it extends further to the east in the mountains to the north and south, is first met with in the valley about half a mile above Kananaskis station, at the place formerly known as Bow River Gap. The rocks at this point have been heavily grooved and striated by the great glacier, which evidently at a former period debouched by the Bow Valley into the foot-hill region. From this place, for six miles, the valley is rather narrow, and is transverse to the direction of the constituent ridges of the mountains, which abut upon it boldly, and are composed chiefly of limestones, with persistent westward dips, generally at rather high angles. To the north, the mountains form part of the Fairholme Range, while the highest summit to the south was named Pigeon Mountain by Bourgeau. This part of the valley is generally wooded, and a couple of small lakes occur in it, which were named *Lacs des Arcs* by the same member of Palliser's expedition. Just west of the second and smaller lake the old trail climbed a steep limestone spur from the mountain to the north, from which a fine view of this noble entrance to the mountain country is obtained. The mountain to the north of this spur is that named Grotto Mountain, also by Bourgeau.

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* Report of Progress, 1882-84. Plate facing p. 80 c.

Wide longitudinal valley.

Beyond Grotto Mountain, a wide, longitudinal valley is entered, and this is occupied by the Bow for a distance of nearly fifteen miles to the north-westward. It averages about four miles in width, and is bounded on one side by the western ridge of the Fairholme Mountains, on the other by Wind Mountain and the range connecting it with Mount Rundle, which, further north-westward, is continued by Cascade Mountain. This wide valley is generally floored by shingly terraces, and is largely wooded, though also containing a number of little prairies. Canmore Station is situated on one of the largest of these, which was formerly known by the Stoneys as "The prairie where they shot the little pine." Near the point at which the course of the Bow again turns to the west, it receives an important tributary—Cascade River,—which occupies the same longitudinal valley still further to the north-westward. Not far from this point, at the southern base of Cascade Mountain, is Banff station. The height of the surface of the Bow above sea-level in this part of its course is about 4,300 feet.

Cascade Coal Basin.

Important coal-bearing region.

The most interesting and important circumstance connected with this part of the Bow Valley is the fact that it is underlaid throughout its length by Cretaceous coal-bearing rocks of the Kootanie series. The coal, which is an anthracite, was first discovered, I believe, in 1883. It is now being opened up, and promises to be of considerable importance on account of its position on the railway line, and its excellent quality. The special map accompanying this part of the report has been prepared to show the distribution of these economically important coal-bearing rocks, which are here described at some length. In this description, in addition to the facts observed by myself in 1883 and 1884, the result of investigations since made by Mr. McConnell in the region represented by the south-western part of the map, is included. The two lower sections shown on the map are by Mr. McConnell, and give a clear general idea of the structure of the entire width of the Cretaceous trough.

Observations by Mr. McConnell.

Dimensions of the basin.

This particular infold of the Cretaceous rocks has already been referred to as having been met with on the Kananaskis River (p. 105 B). It has been named the Cascade basin or trough, from the fact that it runs for a long distance to the north-westward in the valley of the stream so-called. It differs in character from the other areas of Cretaceous rocks found within the mountains, chiefly in the fact of its great length as compared with its width, and the circumstance that the alteration of the contained coal beds has here gone so far as to result in the change of the coal into an anthracite. From its south-eastern

ICAL AND NATURAL HISTORY SURVEY OF CANADA

ED R. C. SELWYN C.M.G., LL.D., F.R.S., DIRECTOR.

GEOLOGICAL MAP

OF PART OF THE

ADE COAL BASIN

ROCKY MOUNTAINS

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extremity on the Kananaskis it has now been continuously traced to the Red Deer River, a total distance of sixty-five miles, and it is still found running to the north-westward, parallel to the enclosing ranges of mountains beyond that river to an undetermined distance. It is probably coal-bearing in character throughout, as coal has been found in a number of places from one extreme of its known length to the other.

The portion of this Cretaceous trough included by the accompanying special map, is about thirty miles in length, and has a total area of over sixty square miles. The quantity of drift material present, and the wide spread of the shingle terraces, above alluded to, in this part of the valley, renders the detailed investigation of the structure of the field difficult; but the great regularity of the strike of the rocks to some extent counterbalances this, and the general structure of the trough is now fairly well understood. The south-western edge of the trough is pretty clearly defined by exposures throughout, with the exception of that portion between Cascade Mountain and Mount Rundle, but the north-eastern is for most of its length entirely concealed. The limestones on this side are known by isolated exposures to extend from a mile to two miles from the base of the mountains, into the bottom of the valley itself, and the strike of the beds indicates the position of their junction with the Cretaceous to be nearly as shown on the map, though pre-glacial denudation may have removed the thin overlapping edge of these rocks for considerable widths in some places, leaving a gravel-filled hollow of unknown width along the outcrop as indicated hypothetically in the section shown in Fig. 8. Outlines of coal-bearing area.

FIG. 6. OVERTURNED ANTICLINAL OF LIMESTONE ROCKS NORTH OF ENTRANCE TO WHITE MAN'S PASS.

The Cretaceous rocks may be described, in general terms, as forming a long, narrow synclinal fold, which, owing to the immense pressure from the south-westward, has been bodily overturned in the opposite direction; the mountain range on the south-west side being composed of an anticlinal of the limestone series, similarly compressed Its general structure.

and folded over on the Cretaceous rocks. Owing to this circumstance the direction of dip of the rocks in the mountains bordering the valley on either side, and in the intervening Cretaceous trough, is almost uniformly to the south-westward. This fact at first induced the belief that the Cretaceous rocks were bounded, along the base of the south-western mountain range, by a very extensive fault, with down-throw to the north-eastward, but further investigation proved this view to be incorrect.

Overturned anticlinal and synclinal. Figure 6 shews the overturned anticlinal in the range to the south-west, as actually observed in the mountains to the north of the entrance to the White Man's Pass, opposite Canmore station. Figure 7 is a sketch illustrating the synclinal form of the Cretaceous rocks,

FIG. 7. SECTIONS OF CRETACEOUS SYNCLINAL SHOWN IN RIDGES BETWEEN BOW AND KANANASKIS RIVERS.

as shown in a series of high ridges which run out from the base of the Wind Mountain range. In this, the wooded slope on the right, together with the distant rough summits, which are vertically shaded, are composed of rocks of the limestone series, while the intervening ridges show five successive cross-sections of the Cretaceous synclinal, in which the character of the folding is clearly evidenced by certain more prominent beds of conglomerate and sandstone. This structure may be seen at a glance, in looking down the valley to the south-eastward from points between Canmore and Grotto Mountain, from one of which the sketch here reproduced was taken.*

mplications. Though thus comparatively simple in its great structural features, this Cretaceous trough is complicated by minor irregularities, which will require to be allowed for in connection with the tracing out and working of the coal-seams; though, on account of the general paucity of exposures, it is yet difficult to do more than indicate their existence. The south-western border of the trough, though spoken of as primarily characterized by the folding back of a limestone anticlinal upon the Cretaceous rocks, is probably in many cases accompanied by more or

* It should be remarked that Dr. Hector clearly recognized the synclinal structure here met with, and shows in his section, No. 24, the same ridges here illustrated. His sketch must have been made from a point near the base of Grotto Mountain. Journals, Detailed Reports and Observations Relative to the Exploration under Captain Palliser, etc., p. 321. See also Quart. Journ. Geol. Soc., Vol. XVII., p. 442, Fig. 11.

less faulting. This is clearly shown on Mr. McConnell's section C–D (on the map), though the actual line of the fault separating the two series is there only diagramatically indicated. In this, and other cases, the character of the pressure to which the rock series has been subjected may have been such as to produce over-thrust faults, in which the older rocks have been pushed bodily over the newer, along a nearly horizontal plane. On the Cascade River, and beyond it, near the north-west corner of the map, the north-eastern border of the Cretaceous is also pretty evidently accompanied by faulting, and it is scarcely likely that the area of the Cretaceous rocks itself is altogether free from such disturbance,—a point to be borne in mind in estimates of the amount of workable coal in given areas. Faults.

There are also indications of a tendency to the production of a minor anticlinal fold in the Cretaceous rocks, near their south-western edge. Such a flexure is clearly shown between the Bow River and the base of the mountains at the entrance to the White Man's Pass, near Canmore, where the exposures are more than usually numerous, and is shown in Fig. 8. Disturbance of the character of that found to occur along the western edge of the Crow Nest Cretaceous trough on Mist Creek (see Fig. 5, page 100 B), may also be looked for in the corresponding part of this Cretaceous infold. Subsidiary anticlinal.

The total thickness of Cretaceous rocks actually known to be represented in this basin is about 5,000 feet, but it is probable that the actual thickness will eventually be found to be considerably greater. The conglomerates seen in the high ridges near Wind Mountain occur at a horizon about 3,000 feet above that which shows the most important coal-seams. Rocks of this character were not seen in the vicinity of Cascade River, and it is probable that the portion of the synclinal there remaining does not include beds so high in the series as these. Thickness of series.

The small number of available exposures, with the fact that most of the coal outcrops do not show well-marked correspondence in thickness, or in the character of the associated beds, has so far rendered it impossible to trace out the course of the coal-seams for any considerable distance along their strikes, or to present a detailed general section in which the relative positions of the various seams and their number might be shown. It is proposed here, therefore, merely to detail the more important facts observed in connection with the various known exposures of coal. Exploration by means of boring will be necessary before the structure and relations of the coal-bearing rocks of this district are fully known. Exposures disconnected.

The first discovery of coal in these rocks is stated to have been made at the point subsequently named the "Cascade Coal Mine," on the river of the same name, about two and a half miles north-east of "Cascade Coal Mine."

Banff station. The coal here occurs in a low, rocky bank on the east side of the stream, and has been experimentally opened by a small drift, run into the bank. The drift was started nearly at the water-level, and it was found that the surface of the rock sloped downward to the east, in consequence of which, the drift in a short distance ran out into the overlying gravelly deposits. The seam is here associated with thin-bedded shaly sandstones and shales, some of the latter being quite dark in colour and finely fissile. A little ironstone in nodular layers occurs both above and below the seam. The dip is S. 53° W. < 35°, and the coal is 2 feet 9 inches in thickness, exclusive of a few inches at the top and bottom, which is shaly in character. The coal looks bright and clean, but is considerably broken up by jointage-planes (a number of which were noted running S. 70° W.), and by slickensiding, evidencing disturbances, which have rendered it rather tender. A seam of three inches in thickness occurs several feet below the main seam, and the total thickness of beds exposed in the immediate vicinity is about one hundred feet.

Analysis. A sample of coal collected at this place, in such a way as to fairly represent the entire seam, has been analysed and carefully examined by Mr. C. Hoffmann. (See Report of Progress, 1882-84, p. 42 M.) By slow coking it was found to give:—

Hygroscopic water	0·71
Volatile combustible matter	10·58
Fixed carbon	81·14
Ash	7·57

Beds below coal North-eastward from the coal exposure, the Cascade River cuts across the general strike of the Cretaceous rocks, and affords a fairly good, though not continuous section of the beds underlying the seam. These consist of dark shales, generally rather arenaceous, interbedded with some shaly sandstones. Though somewhat irregular locally, the dip is found generally to increase, till at the point where the rocks of the limestone series forming the north-eastern edge of the basin are reached, it is at an angle of nearly 80°, with some evidence of faulting about the junction of the two series. The thickness of Cretaceous rocks here underlying the coal is probably at least 4,000 feet. A series of massive sandstone beds, seen about a quarter of a mile east of the coal outcrop, on the upper terrace, was not distinctly recognized in the river section.

Second coal-seam. South-westward from the coal outcrop the rocks are exposed in a number of places for nearly 2,000 feet along the river, but so much local disturbance occurs that it was found impossible to measure a

satisfactory section. At about 1,700 feet along the river, however, a second outcrop of coal occurs, and this, in 1884, had been partly opened up. The seam is here at least several feet in thickness, but it has been badly crushed, and the coal appears in a more or less pulverulent condition. It occupies a horizon probably about 800 feet above the first seam, and may possibly represent the return of the same bed in the reversed south-western side of the main synclinal fold. Cretaceous shaly rocks, which form the lower spurs of Cascade Mountain directly opposite these exposures, pretty evidently represent those described as underlying the first seam further up the river.

Opposite the northern part of Cascade Mountain, the entire width of the Cretaceous trough becomes reduced to about a mile, a circumstance which appears to arise from the folding back of the limestone rocks of the mountain upon the Cretaceous. In the south-eastern base of the mountain, the line of junction of the two formations gradually descends till it reaches the level of the bottom of the valley near the little cascade which gives the mountain its name. Width of basin.

Two and a half miles south-eastward of the "Cascade Coal Mine," on the south-east corner of Section 8, coal seams are again exposed. A shaft has been sunk here to some depth, on the thickest seam, and so far as yet known this locality is the most promising one for the actual extraction of coal. Canadian Anthracite Coal Co.'s shaft.

The lowest, and most important seam, is here 4 feet 6 inches in thickness, and is capable of yielding about four feet of good, clean coal. The dip is S. 35° W. $<$ 30°, and the measures are very regular, the coal being quite solid and of excellent quality. One hundred and thirty-five feet above this seam is a second, 3 feet 10 inches thick, which also shows excellent coal, and between those two main seams are four thinner ones, 9 inches, 24 inches, 8 inches and 12 inches in thickness respectively, in ascending order. Twenty feet above the upper thick seam is still another coal bed, 10 inches thick. There are thus, altogether, seen in these exposures, seven seams in a total thickness of 155 feet of measures, and though but two of these are of workable dimensions, the occurrence of the others is of importance in showing the persistently coal-bearing character of the rocks. Seven coal seams.

The beds including these coals are generally shales and shaly sandstones, which present no very marked characters; but beneath the lowest seam is a thickness of one hundred feet or more of rather massive grey or yellowish sandstones, and a bed of sandstone constitutes the floor of the seam.

At a point nearly a mile west of the position of the shaft, a thin, crumbled seam of coal is partially exposed in a little rocky hill near the bank of the Cascade River, but the intervening rocks are covered, and its relation to the other coal seams is unknown. Thin seam.

The identity of any of the seams here described with either of these at the "Cascade Coal Mine," is also as yet a matter of conjecture, but I have ventured, on the map, to connect the coal-bearing horizon of the two places, the great general regularity of the strike apparently warranting such general correlation.

Analysis. The coal from the shaft, on the lower thick seam, has also been examined by Mr. Hoffmann, who reports fully upon it on page 10 M, (1885). It proves to be a fuel of exceptionally high quality, and gives by fast coking, the following result:—

Hygroscopic water	1.04
Volatile combustible matter	9.15
Fixed carbon	87.18
Ash	2.63

South-west border of trough. Along the base of Mount Rundle, and in the range running south-eastward from it, as far as the entrance to the White Man's Pass, the limestones are seen nearly down to the level of the valley, and the edge of the Cretaceous rocks probably corresponds closely with the base of the steep slopes. No exposures were found in this part of the valley. Carrot creek, though cutting across the strike at right angles, exposes no rocks of the Cretaceous series. Opposite Canmore station, however, and near the entrance to the White Man's Pass, these rocks are seen in a number of places. The section at this place is shown, somewhat diagramatically, in Fig. 8, in which the beds marked with transverse

FIG. 8. DIAGRAMATIC SECTION ACROSS THE CRETACEOUS BASIN NEAR CANMORE STATION.

lines, represent the limestone series, and the vertically shaded layer, the superficial, gravelly deposits and terraces. The actual contact of the limestones and Cretaceous rocks was not seen, but near this line, the latter are almost absolutely vertical, and here Mr. McConnell has found a seam of coal about three feet in thickness. Nearer the Bow River, on the small stream which issues from the pass, a sharp synclinal fold occurs, and shaly beds, containing a thin seam of crumbled coal, appear in addition to the sandstones, elsewhere more prominent. On the bank of the river, three quarters of a mile below the mouth of the

stream, the beds become nearly flat, and contain a seam of good coal, about one foot thick. In shaly layers, associated with this, a number of fossil plants, characteristic of the Kootanie group were collected, among which are *Asplenium distans*, *Anomozamites acutiloba ?* and *Pinus Suskwaensis*.* Fossils.

To the south-east of these exposures, the border of the Cretaceous rocks rises gradually in the slope of the mountains, and in the base of the Three Sisters, forms a considerable part of this slope. Still further on, in the same direction, the area of the Cretaceous trough which continues toward the Kananaskis, is characterized by a series of high Cretaceous ridges, the structure exhibited in which has already been referred to. These have been examined by Mr. McConnell, and afford excellent sections, as shown on the accompanying map. Near the eastern base of the first of these ridges, occur two coal-seams, reported by Mr. McConnell as about 12 and 15 feet thick respectively. This place, which is about a mile and a half from the Bow River and 500 feet above its level, is known as "Marsh's Mine." The two coals are separated by about fifty feet of shales and sandstones, and both have been opened, an adit nearly a hundred yards long having been driven in the upper seam. The coal appears to be of good quality, but has been so much shattered in the manner previously described, that it crumbles on exposure. Mr. McConnell, however, states that coal-seams at or about the same horizon can be traced at intervals for several miles toward the Kananaskis, and believes it to be probable that localities might be chosen in which the coal would be proved to be more solid. The beds above the coals and between that horizon and that of the conglomerates are more or less coal-bearing throughout and contain a number of thin seams. Erect tree-trunks were also observed in this part of the section at several levels. These stand on dark shaly beds, doubtless, representing the soil on which they grow and extend up through beds of sandstones. The two outcrops at "Marsh's Mine" belong to the north-eastern side of the synclinal fold, and the coals do not appear on the opposite or reversed side of the fold. Cretaceous ridges between Bow and Kananaskis. "Marsh's Mine."

As already stated, much exploration, by means of boring, will be necessary before the structure of the coal basin is fully known, but its occurrence on the line of the railway (which actually runs on the Cretaceous rocks for a distance of thirteen miles), taken in connection with the excellent quality of the fuels which it is capable of affording, must be considered as a circumstance of the first economic importance. As the result of the observations made up to the present time, it may be General considerations.

* See Trans. Royal Soc., Canada, Vol. III. Sect. IV.

stated that the disturbances and subsidiary folding of the beds most likely to prove troublesome in following and working the coal, occur, for the most part, on the south-western side of the trough, or in connection with the overturned side of the main synclinal fold. The north-eastern outcrops of the coal seams, therefore, apparently possess the greatest value and should receive the first attention in the development of the field. The greatest difficulty to be apprehended is, undoubtedly, that of the crushed character in which the coal is frequently found, and though such more or less pulverulent coal, is not without value as a fuel, and may be used in locomotive and other engines constructed to burn it, it is, as a salable commodity, much inferior to the solid anthracite. The crushed character of parts of the coal has doubtless resulted from movement affecting the containing rocks subsequent to that which accompanied and probably caused the change of the ordinary bituminous coals of the Kootanie group into anthracite or semi-anthracite. As stated on previous pages of this report, bituminous coals, in other parts of the mountain area, are, occasionally, found in a similar shattered condition.

The north-western continuation of the Cascade Cretaceous trough, as far as the Red Deer River, is described on a subsequent page.

Bow River Valley (continued).

Banff to Castle Mountain siding.

Beyond Banff station, near which the Bow River enters the wide Cretaceous basin just described, the Bow Valley has a west-south-west direction for seven and a half miles to Castle Mountain siding, cutting directly across the run of the mountain ranges. To the south there are three well-marked parallel ranges, ending at the valley in Rundle Mountain, Terrace Mountain and Mount Bourgeau. On the eastern slope of Terrace Mountain, occur several hot springs, which have already become well known. On the north the constituent ridges are not so well marked, the mountains forming part of a wide belt which is still collectively designated as the Saw-back Range, though this name belongs more especially to its western constituent ridge, which ends on the river in Hole-in-the-wall Mountain, and is composed of vertical beds of limestone. In this part of the valley a couple of small lakes, and some swampy meadows again occur, recalling those which are found in the similarly situated transverse part of the valley east of Grotto Mountain, and like those, evidently formed by interruption of the drainage by material washed in from the neighbouring mountains. The rocks composing the mountains on both sides of the valley are almost entirely of the limestone series, and show continuous high south-westward dips.

From Castle Mountain siding to Bow Lake, the valley preserves a nearly direct course to the north-west. For thirteen miles this course is oblique to the general direction of the mountains, but after passing the south end of Castle Mountain, the trend of the mountain ranges changes to the same direction with the valley, which follows the axis of an important anticlinal, in which Cambrian rocks are brought to the surface, for at least twenty-six miles. The first portion of the valley is rather irregular in width, but further on it becomes a wide, definitely bordered and parallel-sided trough like other important longitudinal valleys of the mountain region. Castle Mountain to Bow Lake.

Castle Mountain is in appearance one of the most remarkable on the Bow Valley, and contrasts markedly with those forming the western border of the Saw-back Range,—from which it is separated only by Johnson Creek (called also Silver Creek). Its higher part is formed entirely of rocks of the great limestone series, which apparently in the main, form a shallow synclinal, and have low, regular dips. As first seen from the south-eastward, its extremity appears as an almost isolated index-like pinnacle, but on closer approach this is found to be merely an outlying peak of a range of rampant-like cliffs which border the Bow Valley on the east for a distance of ten miles. Deposits of purple copper ore have been found in a number of places on and near Copper Mountain, and mining locations have been staked out, but as far as I am aware no great amount of prospecting work has been accomplished on any of them. Castle Mountain. Copper.

Opposite the south end of Castle Mountain, across the Bow River, is Copper Mountain, 8,500 feet in height. This mountain is so named on account of the occurrence of similar deposits of copper ore, and these, as work was in progress toward their development, were examined with some care in 1884. Copper Mountain.

Copper Mountain is separated by the deep, narrow valley of Red Earth Creek from the higher summit to the south-east known as Pilot Mountain, in which beds of the limestone series appear nearly horizontal or forming a low anticlinal. The summit of Copper Mountain has a crescentic outline, concave toward the north-west, with a couple of short, high ridges, interpolated between the horns of the crescent. Its eastern slopes are densely wooded, and were not closely examined, but appear to consist of limestones, also lying at rather low angles of inclination. Toward the western end of the mountain, however, these beds became quite vertical, with a north-and-south strike, and its extreme western part is composed of quartzites referable to the Cambrian series, also in a vertical attitude, as shown in the eastern part of section No. 1. The most important occurrences of copper ores are in the vertical portion of the limestones series a short distance east of its

Copper ores. junction with the quartzites, and appear in the vicinity of one of the spurs above mentioned, three and a half miles nearly due south from Silver City station, at altitudes between 7,000 and 8,000 feet.

Work carried on. The theory in accordance with which work was being carried on at the time of my visit, was, that the ore-deposit ran north-and-south along the spur just referred to, more or less parallel to the strike of the limestone. Copper ore had been uncovered at several places along the crest of the spur within a length of half a mile, and an adit had been run in from the valley at its eastern base for a distance of over 200 feet. It would be necessary to continue the adit for several hundred feet further before it would reach the presumed line of the ore-deposit, and no ore had, so far as I could learn, been found in the progress of the drifting.

Principal exposures of ore. The four principal points at which some work had been done on the edge of the spur, in order from north to south, presented the following appearance:—(1). Quartz seams, in shattered limestones; the seams running nearly north and south, with an eastward dip $< 40°$. Some small specimens of good ore, but no appearance of a continuous vein. (2). A mass of quartz running N. 20° E. through the limestones, nearly vertical. This includes some small rich seams of ore, and a few bunches or pockets. (3). A fairly well-defined quartzose vein, about two feet thick, running east and west, with southward dip $< 80°$. This is colored by copper carbonates, evidently produced from the decomposition of sulphides, and is said to have yielded several fine masses of ore. (4). This is a somewhat irregular vein, but, like the others, has not very well defined walls. It runs across the edge of the spur S. 80° E., with southward dip $< 80°$. Where best developed the width is about seven feet, and is made up of a foot of barren granular quartz at each side, with about five feet intervening of good ore, consisting of copper pyrites, purple ore and copper glance disseminated, generally in pretty fine granules, through a quartzose matrix. It is much decomposed, with blue and green carbonates filling crevices, and the limestone bordering it is considerably fissured, and occasionally holds a little ore. This is the most promising of the openings, and it will be observed that both this and No. 3, run directly across the ridge or spur and the strike of the limestone beds.

Summit of Copper Mountain. The somewhat plateau-like top of Copper Mountain is deeply covered with angular rocky fragments, which are doubtless due to the prolonged action of the frost and weather. Among these are a number of masses of considerable size, of porous, yellow and blackish gossan, which have apparently come from the decomposed outcrop of a copper vein, which must run across the summit, probably in an east and west bearing. From the size of the fragments, the vein is likely more important than

those above described, and it would not require much work to ascertain this point. On analysis the gossan proved to contain neither gold nor silver. Loose fragments of rich ore have here been found also, on the southern slopes of the mountain, and one of these, consisting of nearly pure, purple ore, weighed about seventy pounds. It is evident that the copper-bearing district is here somewhat extensive, and not improbable that rich deposits may eventually be opened up. The opinion formed on the examination of this vicinity was, however, that the ore deposits are irregular, and consist rather of pockets or "gash veins" than of true persistent lodes. Copper-bearing area.

Specimens of the ores from Copper Mountain which have been analysed by Mr. Hoffmann, though yielding high percentage of copper, contained neither gold nor silver. In the examination of the vicinity of Copper Mountain, I was accompanied by Mr. J. Heely, the original discoverer, to whom thanks are due for his assistance. Character of ore.

From Copper Mountain it is not difficult to travel westward, in a nearly direct line, to the Twin Lakes, at the base of the main range. The information gained with regard to the rocks in this locality appears in section No. 1. The structure is that of an anticlinal, with nearly vertical beds on the east side, but showing dips at angles of about 20° to the west. This is the continuation of the anticlinal of the upper Bow Valley. To the west of, and below the limestones of the vicinity of the copper deposits, is a considerable thickness of white and grey quartzite, with some conglomerates and schists. The centre of the anticlinal is then occupied, for a width of nearly two miles, by schistose rocks, of grey, blackish and brownish colours. They are chiefly argillites, but show incipient crystallization, which gives them a glossy appearance. In some places, slaty cleavage occurs, but the rocks generally split up parallel to their bedding. Bands of quartzite are found throughout. Almost the entire eastern front of the watershed range is composed of quartzites and other rocks of this great Cambrian series, as more fully described in connection with the Vermilion Pass (p. 119 B). The total thickness of the Cambrian rocks shown in this anticlinal, must be at least 5,000 feet. Much white or rusty crystalline quartz is scattered over the district characterized by those schistose beds, and is derived from veins which traverse them in all directions. Near the Twin Lakes, fragments of galena occur, and a vein of this mineral has been discovered and located here by Mr. Heely. A specimen, in which the galena constituted only a small part, yielded about half an ounce of silver to the the ton, on analysis by Mr. Hoffmann. (Report of Progress 1882-84 (p. 6 M M.) Rocks from Copper Mountain to Twin Lakes. Galena.

The mountains between Copper Mountain and the watershed range,

are, in consequence of the softer nature of the schistose rocks, charactered by low, rounded summits and ridges, which, however, rise to heights exceeding 7,000 feet. The upper slopes are almost bare, Lyell's larch being the most abundant tree.

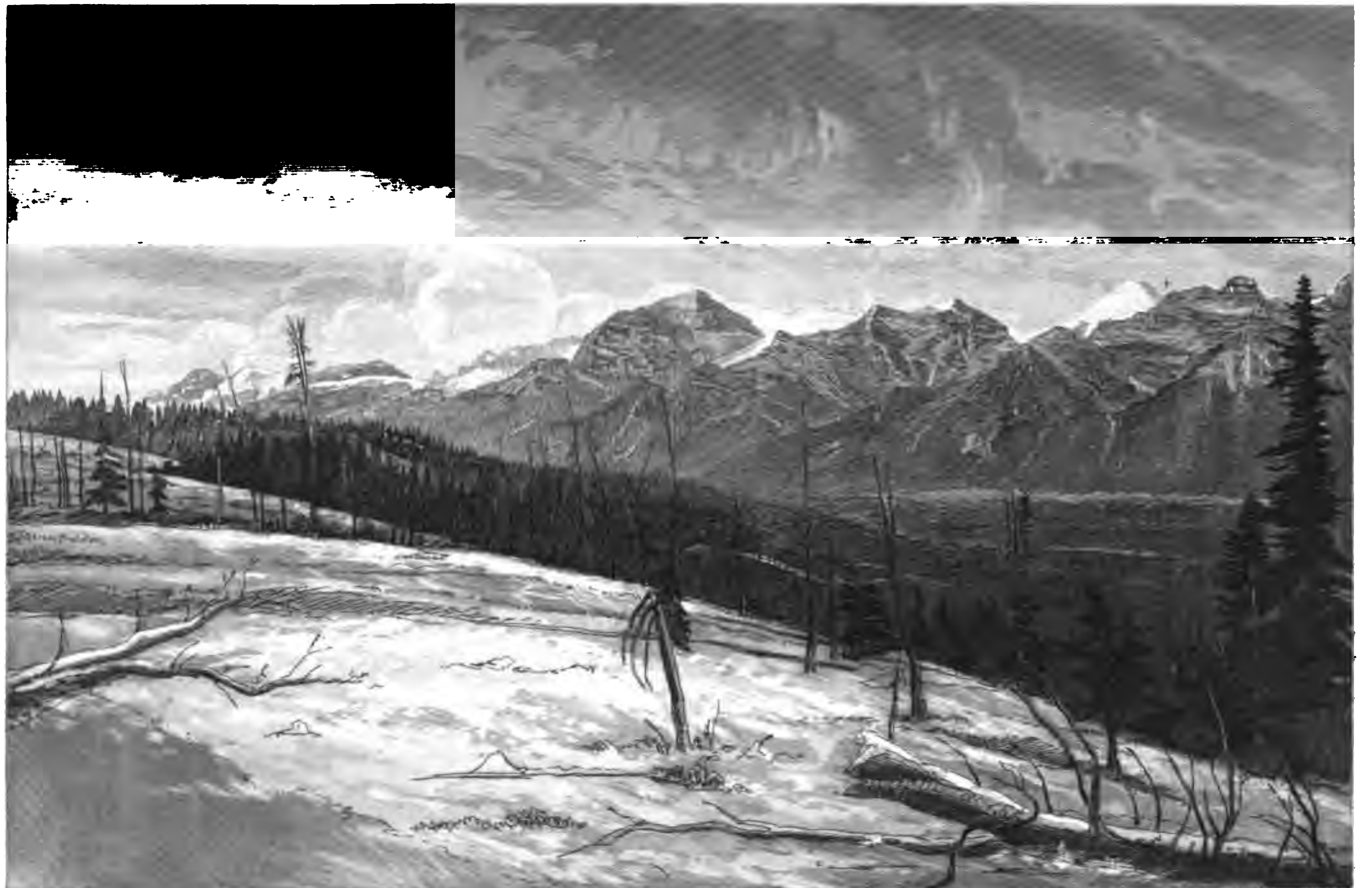
Twin Lakes. The Twin Lakes lie at the base of the scarped and nearly vertical front of the watershed range, which rises above them in stupendous cliffs, in the rifts and hollows of which, snow remains throughout the year. The lakes give rise to a small stream which reaches the Bow near Silver City.

View from Copper Mountain. The summit of Copper Mountain affords a very fine and extensive view, both of the upper part of the Bow Valley, and the wild mountain country to the south. Assiniboine Peak, with its remarkable fringe of glaciers, was best seen from this point, though about twenty miles away, and the escarpment-like front of the main, or watershed range of the mountains, may be traced for a great distance. The whole upper part of the valley of Red Earth Creek, is also in view, and its remarkable width, and light slopes, contrast strongly with the more rugged appearance of other parts of the region. These characters are due to the fact that it follows the run of the belt of schistose rocks already mentioned. These rocks were seen by Mr. McConnell near the summit of Simpson's Pass where the Cambrian area appears to terminate.

Bow Range. The mountains on the south-west side of the Bow Valley, from Silver City onward, are very bold and high, and include Mount Lefroy, the most lofty yet actually measured in this region, with an altitude of 11,658 feet. The plate facing this page, illustrates the appearance of this range as seen from a high spur of Mount Hector, on the opposite side of the valley. The conical, snow-covered peak on the right is Mount Lefroy, while that near the centre of the view has been named Mount Temple. The greater part of the mass of these mountains is composed of quartzites and slaty or schistose rocks, with uniform, low, south-westward dips. Massive limestones appear near the summits of many of them. The Slate Mountains on the opposite side of the valley have, generally, rounded forms quite different from those of the Bow Range and Castle Mountain. Several small streams enter the Bow from the mountains on the south-west, but the greater part of the water from this range flows off in the opposite direction. On the north-east side, Baker Creek is an important stream, and Pipe-stone

Pipe-stone Creek. Creek may be called a river.* Its name is given on account of the occurrence on it of fragments of soft, fine-grained, grey-blue argillite, which the Indians have used in the manufacture of pipes. Some

* *Pa-hook-to-hi'-agoo-pi'-wap-ta* in Stoney, *Moni'-spaw-gun-na-nis-si'-pi'* of the Crees, signifying "Blue Pipe-stone River."



British American Bank Note Co. Montreal

BOW VALLEY AND MAIN RANGE OF ROCKY MOUNTAINS

LOOKING SOUTH FROM HIGH RIDGE, SIX MILES N.W. FROM LAGGAN

parts of this portion of the Bow Valley are broken by low, rocky hills, composed of slaty Cambrian rocks.

Bow Lakes.

Northward from Laggan station, to the first of the two lakes in which the Bow rises, the valley preserves similar structural characters, but is more densely and uniformly wooded than before, and often very swampy. The first of the Bow Lakes (where our examination ended in this direction), is a fine sheet of water, four miles in length, and at an elevation of 5,530 feet above sea-level. Its lower end extends into the valley, and is separated from the river only by a narrow tract of flat land, composed of gravelly and other detrital material. The greater part of the lake, however, lies in a deep valley between the northern end of the Waputtehk Mountains and Sheep Mountain, both of which rise from it almost perpendicularly. On the mountains at its upper end is a considerable glacier, fed by a large snow-field of unknown extent to the westward.*

Kicking Horse Pass.

The railway, beyond Laggan, follows Noore's Creek for three miles, after which it ascends by the valley of a small tributary stream to the actual summit of the Kicking Horse Pass, at an elevation of 5,296 feet (on the railway grade) above the sea. The transverse valley forming the Kicking Horse Pass, where it traverses the watershed range, repeats in its main features those of the Vermilion Pass, previously noticed. It is not necessary here to enter into any general discussion as to the origin of such transverse valleys, but it may be stated that the present conditions fail to explain the origin of this comparatively wide trough, which has been excavated at right angles to the watershed range. It appears highly probable that the stream now flowing to the Bow may originally have had its sources much further west than the present summit, and that the head-waters of the Kicking Horse, in consequence of the greater fall on that side, have cut back eastward, reducing the area which drains to the east. Bedded gravel deposits occur about the actual summit, in positions which imply the presence of a considerable body of water at levels higher than are possible under the actual circumstances. Rock surfaces near the same place were observed to show glacial striation in an eastward direction.

Rocks.

Geologically, the mountains about the summit have, in the main, a synclinal structure, rocks referred to the great limestone series coming down to the level of the bottom of the valley for about two miles near the height of land. Below these, a short distance west of the Kicking Horse Lake, a few fossils were discovered in 1884, in exposures newly made along the railway line, by members of the visiting party of the British Association for the Advancement of Science.† Among

* The Bow Lakes are called *Mi'-nis-ne-im-ne* in Stoney, *Os-kow-wioo-si'-pi'-sa-ga-he'-gun* in Cree, meaning Coldwater Lakes.

† See p. 14 B.

Cambrian fossils.

specimens obtained at that time, Mr. C. D. Walcott has recognized *Olenellus Howelli* and *Olenoides lævis*, trilobites characteristic of the Prospect Mountain Group of Nevada or Middle Cambrian.

General geological features.

The geological structure of the mountains near the Kicking Horse River, is, if anything, more intricate than that of most parts of the mountains, and as it is now being investigated in detail by Mr. McConnell, any description which I might give of it from my own reconnoisance work would probably be greatly modified by the result of his examinations, which will shortly be published. On the map, an attempt is made to separate the quartzite and slate series, from the overlying great limestone series which is referred to the Devonian, or Devonian and Carboniferous. It should be noted, however, that the existence of passage beds between these and the quartzite series was suspected in this place, and that Mr. McConnell informs me that he is of opinion that Cambro-Silurian and Silurian rocks also probably occur here. It may be stated also, that the slaty and schistose rocks seen near the Otter-tail, closely resemble those found on the continuation of the same strike in the Vermilion Valley, while those near the mouth of the Beaver-foot are quite analogous to rocks seen further to the south-eastward in the Beaverfoot-Kootanie Valley.

Ore deposits.

Since the date of my examinations, also, a number of metalliferous deposits have been discovered, and some of these have been opened and prospected to a considerable extent. Most of these are in the vicinity of the mouth of the Otter-tail, and near Mount Stephen. The ores so far examined in the laboratory of the Survey consist largely of galena, which is generally associated with more or less copper pyrites. They contain, however, but a low percentage of silver, and gold is practically absent. Some of the lodes are reported as wide and continuous. Assays of a number of specimens will be found in Mr. Hoffmann's reports. (Report of Progress, 1882-84., Report M M. Annual Report, 1885., Report M.)

Kicking Horse Valley.

The descent of the branch of the Kicking Horse which rises in the pass, is at first very rapid, but on reaching the bottom of the valley, this branch is joined by a larger stream, at the head of the valley of which a fine glacier appears. For several miles almost the entire width of the valley is occupied by gravelly bars, evidencing the great volume of water which at some seasons must descend from the mountains. On the south side of the valley are Cathedral Mountain and Mount Stephen, picturesque spurs from the northern end of the Bow Range. Further down, the valley of the North Branch, which is remarkably wide, opens northward, and several glaciers and snow-fields appear on the mountains, which a few miles further up rise to heights of 9,000 to 10,000 feet. The river makes an acute angle round the south end of

of Mount Hunter, and forms a fall of about forty feet in height near the apex of this angle. Down to Palliser station, the valley continues moderately wide, but below that point becomes gradually more constricted, and before reaching the Columbia Valley, flows for some miles in a deep cañon, falling from ledge to ledge as a wild torrent.

Devil's Lake and Vicinity.

Devil's Lake,* ten miles long and about half a mile in width, occupies part of a very remarkable, transverse valley, which runs across the outer ranges of the mountains to the east, separating the Palliser Range from the Fairholme Mountains. It has already been stated, that this valley presents all the appearance of having at some former time been that of a large river, and it is probable that at a period antecedent to that of the glaciation of the mountains, the Bow River flowed through it. The valley is parallel-sided, and bounded to the north and south by high and abrupt mountains. Its western part is now occupied, for its whole width, by the lake, while to the east, its nearly level floor is formed by drift deposits, and two small lakes have been formed by the damming of the valley by the delta deposits of lateral torrents. The Devil's Lake has an approximate elevation of 4,800 feet, and discharges by a rather small, tortuous and somewhat sluggish stream, into the Cascade River, above Banff. The water of the lake is clear, and it is evidently deep, though very often showing a shallow border, which, at a few hundred yards from the shore, ends suddenly with a terrace-like front. This is a feature not uncommonly found elsewhere, but it is here apparent, through the clear water of the lake, that this shallower border is generally formed of gravel deposits, which have been cemented by calcareous matter into a species of conglomerate, which is broken into irregular blocks, about the outer or escarpment-like edge.

Devil's Lake.

Shallow border of lake.

The forms of the mountains about the lake are particularly varied and bold, and Peechee's Mountain, to the south, rises to a height of about 10,000 feet. Fans, or delta deposits from lateral valleys project short distances into the lake, and it is finally terminated to the east by one of these of dimensions larger than usual. Beyond this, the valley appears to rise gradually eastward, obtaining its greatest height at its eastern opening to the foot-hill country, where it is stopped by irregular terraces and ridges, some of the latter being, very probably, of the nature of moraines. A short distance farther east, the Ghost River is met with. Its valley is here excavated in deep, gravelly deposits, which,

Devil's Gap.

*Called *M'ne'-sto*, or "Cannibal's Lake," in Stoney, *Ki'-noo-ki'-mow*, or "Long Lake," in Cree.

in some places, form low cliffs, having become cemented by a calcareous deposit. It would appear that the covering of detrital deposits is very deep, both in the Devil's Gap, and on this part of the Ghost River. The river, when not in flood, entirely disappears here, leaving a wide, dry gravel-bed for some miles. The smaller lakes in the Devil's Gap have no visible outlets, and are evidently subject to considerable increase in spring, when surface water is, doubtless, supplied more rapidly than the drainage through the gravel beds can remove it. No rock in place is seen in any part of the flat valley of the Devil's Gap, which is bordered on both sides by towering cliffs, in some places perfectly vertical to a height of 1,000 feet or more. Figure 9, gives an idea of the general appearance of this singular valley, as seen in looking in an eastward direction out towards the foot-hills from the west end of the larger little lake.

FIG. 9. DEVIL'S GAP VALLEY, LOOKING EAST.

Rocks. The rocks seen near the valley are almost entirely limestone, which, though with minor flexures, appears to dip generally south-westward, along the lower two-thirds of the lake. The rocks then form a low anticlinal, next a low synclinal, and at the eastern base of the range are found with the usual south-westward dip. The character of the junction of the limestones with the Cretaceous rocks of the foot-hills, is here unknown. The angles of inclination of the beds throughout the valley are, so far as observed, uniformly rather low.

Fossils from Cascade Mountain. On the slopes of Cascade Mountain, in fragments derived from the higher cliffs, a number of fossils have been found, but these, for the most part, are poorly preserved. They indicate, however, a Devonian or Carboniferous age, and include, besides numerous fragments of

crinoids, two species of *Productus*, *Athyris Royssii* (?) *Atrypa reticularis*, *Orthis*, sp. (a resupinate form), *Spirifera*, two species, *Straparollus Nevadensis* (?) and a *Cypricardinia*.

The beds immediately underlying the Cretaceous rocks on the north-east side, near the mouth of Devil's Creek, are calcareous sandstones, passing, in some places, into quartzites, and weathering to reddish or yellowish tints. These resemble those elsewhere seen in the upper part part of the limestone series (See pp. 73 B., 74 B., 113 B., etc.) and are probably of Carboniferous age. Their thickness at this place is several hundred feet, and they form a series of low, rough, rocky ridges, which run obliquely across the Cascade Valley. Moderately well preserved specimens of *Productus semireticulatus*, of a *Rhynchonella*, (apparently closely related to *R. mesacostalis*) and an *Aviculopecten*, (probably a new species), were obtained from them. **Fossils from Cascade River.**

In rocks derived from the mountains about the gorge which opens on the valley from the north, a mile and a half east of the upper end of Devil's Lake, a specimen of *Ptychoparia Oweni*, M. & H., indicating a Cambrian horizon, was found, but no outcrops of the Cambrian quartzites or slaty rocks were observed. At the same place, it was noted that in the wash from the gorge, pieces of soft shales occur, resembling those of the Cretaceous. **Cambrian.**

Upper Valley of Cascade River and Route thence to the Red Deer.

The route here described follows the northern continuation of the Cascade Cretaceous trough, and was traversed for the purpose of ascertaining its length and character. (See p. 134 B.)

The stream now called the Cascade River, is roughly indicated, but not named, on Palliser's map. It is designated *Pa-ma-sae-wap-ta* in Stoney, *Ka-kĭs-kĭ-kwe-niht-sĭ-pĭ* in Cree, both names referring to a story of a murder, in which an Indian is said to have cut off the head of a companion. **Cascade River.**

For three miles above the mouth of Devil's Creek, the river flows in a rocky gorge, between limestone ridges, close in to the mountains which form the north-east side of the valley. The eastern edge of the Cretaceous rocks runs nearly up the centre of the valley, directly across the bend of the river. A straight, narrow, subsidiary valley marks the junction of these rocks and the limestones. Both series at first dip westward at high angles, but further north the Cretaceous rocks dip at a low angle to the east, and their junction with the limestone series is evidently a faulted one. Nine miles above the mouth of Devil's Creek, a stream from the mountains to the eastward, supplies **Upper part of Cascade Valley.**

about half the volume of the Cascade River, and following the valley five and a half miles further, Saw-back Creek joins from the range of the same name on the west. A low, steep-sided ridge here occupies the centre of the valley. This, seen from the south-eastward, appears conical in form, and the course of the valley is so direct that it may be observed from the vicinity of Canmore, twenty-five miles distant in that direction. The valley, in this part of its length, averages about a mile in width, and is, for the most part, pretty densely wooded up to the mouth of the eastern tributary stream above mentioned. Thence to Saw-back Creek there are a number of little open meadows. The mountains to the west are connected with Cascade Mountain, and form a continuous range from 8,500 to 9,000 feet in height, though decreasing gradually northward, and terminating near the mouth of Saw-back Creek, where the next range to the westward becomes that which borders the valley. In the north part of Cascade Mountain, the Cretaceous rocks form the lower third of its total height above the valley. In the mountains further on they rise gradually till they occupy about half the height of the mountain sides. The line of junction then descends again in the slopes, till it reaches the level of the valley. The limestone rocks, forming the higher parts of the range, are in several places clearly seen to preserve the anticlinal character found in the Mount Rundle range, further to the south-eastward; but the anticlinal has not been so completely overturned on the Cretaceous trough, and it runs out in a point, in the northern part of the ridge near the mouth of Saw-back Creek. Rocks which appear to be Cretaceous, are seen on the western side of this mountain range, some miles southward from this point, and it is probable that a subsidiary infold of the Cretaceous occurs behind the first range, as indicated on the map, though its dimensions are shown only conjecturally.

Saw-back Mountains.

Mountains east of valley.

The mountains on the opposite side of the valley are broken in their southern part by a number of deep transverse gorges. South of the large eastern tributary, previously mentioned, a narrow band of the Cretaceous rocks is seen high up on their slopes. This evidently represents the eastern edge of the main Cretaceous synclinal let down by a fault parallel to its direction. The same band is probably continued for a couple of miles north of the tributary valley, as represented on the map, where the eastern bounding mountain ridge becomes regular and unbroken, forming a steep, nearly bare range, in which the limestone strata increase in angle of dip till they eventually become almost vertical. The whole width of the Cretaceous trough is less than a mile, a short distance south of Saw-back Creek.

North of the confluence of Saw-back Creek, the Cascade is a small, rapid stream, and both its immediate valley and the slopes of the

Source of Cascade River.

adjacent hills are rough and wooded, for two or three miles. Beyond this, in consequence of the increasing altitude, they become open, and the stream is found to be formed by three brooks, flowing from valleys in the Cretaceous hills. The trail follows the eastern valley, and the summit is reached at a distance of five and a half miles from Saw-back Creek, at an altitude of 6,549 feet. A well-marked trough, like an old stream-valley, runs across the summit. It is blocked here and there by newer delta deposits from lateral tributaries, one of which has produced a small pool, in which rises a little stream, flowing in the opposite direction. This stream, falling about 500 feet in four miles, reaches the deep, transverse valley of the Panther River,* a tributary of the Red Deer, which flows eastward through the limestone range to the right.

Panther River.

The same transverse valley is continued to the westward into the eastern front of the Saw-back Range, but its upper part is wide, and bordered by the rounded and wooded Cretaceous foot-hills of the Saw-back Range. Still continuing in the same general northward direction, a branch of the Panther River is followed up to a second summit, five miles beyond it, with a height of 7,263 feet. The valley of this stream is at first a deep narrow ravine, which the trail follows on the east side. Near the summit, however, it becomes wide and moor-like, with low thickets of willow and birch, and rough tussocky grass. Beyond the summit, a stream, which rises in the hills to the east, enters the valley, and turning at right angles, joins the main Red Deer River in five miles further. Its valley is generally wooded, and the stream flows in a deep, narrow gorge. The height of the Red Deer at the mouth of this stream is, approximately, 5,500 feet.

Panther River to Red Deer River.

A short distance north of Saw-back Creek, the Cretaceous trough attains a width of about three and a half miles, and about the sources of the Cascade, is a region of Cretaceous hills, which, though rounded in outline as compared with the rougher aspect of the limestone mountains, reaches heights of about 1,000 feet above the summit level. The plane of the present surface of the country is evidently near that of the top of the limestone series and base of the Cretaceous, and, in consequence of this, the flexures of the strata render the outlines of the formations complicated and irregular. Opposite the summit, on the east, the Cretaceous appears to fold completely over the limestone ridge, which has up to this point been continuous, as shown on the map. Further on, the denuded crest of this anticlinal again exhibits the limestone rocks, which resume as a continuous ridge, in the Bare

Complicated outlines of formations.

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* Panther River is probably a sufficiently near approach to the Indian name of the stream, which signifies "The river where the mountain lion was killed." This, in Stoney, is rendered *It-mos-tunga'-moos-ta-ga-te'-wap-ta'* ; in Cree, *Mis'-si'-pi'-sioo-ka'-nipa'-hiht-si'-pi'*.

Mountains. The western side of the Bare Mountains is, however, formed altogether of Cretaceous sandstones, which dip westward at an angle of about 60°. The relations of the Cretaceous and limestone series, in this range where cut across by the Panther River, as they appear in the mountain on the north side of the valley, are illus-

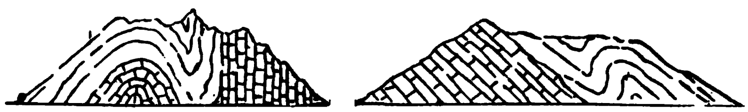

FIG. 10. NATURE OF JUNCTION OF CRETACEOUS AND LIMESTONE SERIES IN BARE MOUNTAINS.

trated in the section to the left on Fig. 10. The section to the right of the same figure, illustrates, diagramatically, the flexures shown in White's Mountain, forming the north end of the Bare Mountains on the Red Deer. In both sections, the transversely marked beds represent the rocks of the limestone series.

Character of Cretaceous trough.

From Saw-back Creek to the Red Deer, the Cretaceous rocks preserve their general character as a synclinal, with overturned western edge. They dip beneath the eastern border of the Saw-back Range at angles of 30° to 40°. Much higher dips are, however, often met with in the central part of the synclinal, where the beds are sometimes vertical, and evidently much disturbed and broken. The Cretaceous rocks on the eastern edge of the synclinal usually dip westward at angles of about 60°. The various streams, along which the trail runs, have excavated the greater part of their valleys, in a belt of dark, soft, shaly rocks, which appear to be continuous throughout. East of the Bare Mountains is a second, smaller Cretaceous infold, and the explorations of Mr. McConnell, in 1885, have shown that there are additional considerable areas of Cretaceous rocks, still further eastward between these and the last limestone range which separates the mountain district from that of the foot-hills. Beyond the Red Deer, the Cretaceous rocks of the Cascade basin still continue as a wide belt running to the north-westward. We did not, however, follow them further in this direction, but turning westward by the valley of the Red Deer, travelled to the Pipe-stone and upper valley of the Bow.

Coal-seam on Red Deer.

In the northern face of Prow Mountain—a bare, bold, limestone peak—the overturned character of the western edge of the Cretaceous trough is clearly seen. On the Red Deer River, at its base, and quite close to the overlapping edge of the limestones, is an exposure showing a coal-seam several feet in thickness, but so much crumbled and broken that the precise width could not be ascertained. Coal was also observed

in the bed of a stream joining the river from the north. A specimen from the bed on the river, was found to yield a firm coke, and to be, so far as composition goes, an excellent fuel, giving 2·9 per cent. of hygroscopic water, 62·95 per cent. of fixed carbon and only 4·89 per cent of ash (see p. 7 M).

The Red Deer River, where first reached, is a small stream, about a hundred and fifty feet wide by six inches or a foot deep. Just above the coal outcrop, it forms a fall about thirty feet high over limestone rocks. Above this place, the valley turns to the south, and becomes very wide, a character which it preserves for about seven miles, or to the base of Mount Douglas. The lower, or northern part of the wide portion of the valley is generally wooded, and but small areas of the forest have been burnt. The timber is, however, of inferior quality. Near Mount Douglas the valley becomes open, and is characterized by gravelly hills. Several streams join the river in this part of its course, one of which, coming from the valley at the east base of Mount Douglas, is reported to rise in a lake. The south-eastern slopes of the mountain are entirely covered by an extensive snow-field, which gives rise to a glacier which fills the head of the valley just mentioned. The head of the valley, which lies between Mounts Drummond and Macoun, is similarly blocked by a wide snow-field and glacier, and one part of the summit of Mount Macoun is crowned by a cliff of blue glacier-ice, fragments of which, from time to time, fall over the vertical face of the mountain into the valley beneath. The mountains in this vicinity attain heights of 8,000 to over 9,000 feet, and are singularly varied and striking in form. The source of the Red Deer, at the summit of the pass between it and the Pipe-stone, is found in a small lake, at an elevation of 6,660 feet above the sea-level. From this summit a rapid descent is made to the valley of the Little Pipe-stone, the sources of this stream being at a distance of seven miles, in the mountains to the south. The valley of the Little Pipe-stone is rather wide for a stream of such small dimensions, and is, for the most part, thickly wooded. It joins the Pipe-stone at a height of 5,860 feet.

Red Deer Valley.

Glaciers.

Head-waters of Red Deer.

The rocks actually observed on the upper part of the Red Deer, and along the Little Pipe-stone, are almost altogether limestones, and the whole of this part of the mountains is coloured on the map as belonging to the great limestone series. It is, however, more than probable that areas of the underlying series of quartzites and slaty rocks come to the surface in some places, as the region is much disturbed, and the dips often high. In the mountains between Prow Mountain and Mount Douglas, the strata become quite vertical. The beds in Mounts Drummond and Douglas, dip south-westward at angles of about 20°, those in Mount Macoun, in the same direction, but at a lower angle. The range

Character of rocks.

on the east side of the Pipe-stone Valley, shows dips in the opposite direction, indicating a general synclinal structure. Cambrian quartzites and slaty rocks occupy the valley of the Pipe-stone, in the form of an anticlinal, the axis of which rises southward, causing the limestones to recede from the valley as it approaches the Bow. The higher parts of Mount Molar (of Hector) and of the Mountain to the south of it, in the same range, to which I have given the name of Mount Hector, are composed of rocks of the limestone series, but the high, long spur, which runs southward from Mount Hector, is formed altogether of greenish, reddish, or purplish, slaty or shaly argillites, and quartzose conglomerates of the Cambrian series. The range, which includes Mounts Molar and Hector, has a synclinal structure, and is flanked by the Cambrian anticlinals of the Pipe-stone and Bow valleys, on the east and west sides respectively.

Mount Hector.

View from Mount Hector.

The plate illustrating the Bow Range, facing page 138 B, is from a photograph taken from a point on the long southward spur of Mount Hector, just alluded to, above the timber line, at an elevation of about 7,000 feet, when these higher parts of the mountains were covered with freshly fallen snow. The plate, however, includes only a portion of the magnificent panorama of the central and higher part of the Rocky Mountains which this point affords. It commands the entire length of the Bow Valley, from the upper lakes to Copper Mountain, and will well repay any one who may be sufficiently enterprising to reach it. A trail suitable for horses, could be made from Laggan station to this place at a moderate expense.

The Columbia-Kootanie Valley.

Tobacco Plains.

To complete the general description of the routes travelled within the portion of the mountains included by the present report, it now only remains to add a few notes respecting the great valley of the Columbia and Kootanie rivers. It has already been noticed at some length in connection with the preliminary chapter on orographic features (p. 28 B), which may be referred to in this connection.

The part of the Kootanie Valley near the forty-ninth parallel has long been known as the Tobacco Plains. It is entitled to be named a plain only in comparison with the neighbouring mountainous regions, and the continuously open country extends but a few miles north of the international boundary. The bottom of the wide valley is here composed of gravelly hills which appear to represent moraine ridges in a more or less degraded state. These become lower on approaching the river, and are surrounded by wide, gravelly terraces, which in sections on

the Tobacco and Kootanie are seen to consist of white silt, with interbedded coarse gravelly layers, and are probably due to the closing epoch of the glacial period, when the valley was filled by an extensive body of water, into which turbid glacier streams from the neighboring mountains discharged. As already mentioned, the total annual rain-fall must here be very small, and it is in consequence of this fact that the 'plains' have remained without a forest covering. They are characterized by scattered groves of the yellow pine, with larch and Douglas fir. The soil is in general rather light, and sandy or gravelly in character, but where the silty deposit forms the surface, it is capable of producing fine crops when irrigated. Numerous steep-sided hollows, without outlets, some of which hold pools and small lakes, occur among the moraine hills, and here and there pit the surfaces of the terraces. Large ice-carried blocks of the rocks of the mountains are in some localities pretty thickly scattered, but rock in place seldom appears in the valley.

Northward to the Elk River, the same conditions prevail, but the country becomes more generally wooded, the open tracts being almost restricted to the terraces along the Kootanie. The Elk is crossed near its mouth by a ford, which, except at low water, is deep, and dangerous owing to the rapidity of the current. Valley northward to Elk River.

From the Elk to Wild Horse Creek, the wide belt of low country lying between the Kootanie and the western range of the Rocky Mountains continues to maintain the general character of that further south. Between the Elk and lower part of the Kit-a-mun River and Sand Creek is an extensive tract, with scattered groves of yellow pine, and the other trees previously mentioned, having a park-like appearance, and capable of affording abundant pasturage. Here some of the morainic ridges were observed to have a more or less distinct semicircular form, open to the northward. The soil is usually light, but the flats near the river and some of the lower terraces, which are of considerable width, would be suitable for cultivation if irrigated. On approaching the base of the mountains the surface becomes generally wooded, and for some miles south of Wild Horse Creek it is rough and very evidently composed of slightly modified moraines. Country north of Elk River.

Bull River, like the Elk, is difficult to cross at high water, and a narrow bridge has been thrown over it at the point at which it leaves the mountains, where it appears as a wild torrent, flowing for half a mile or more, in a deep and very narrow cañon. As a considerable detour is necessary in order to reach this bridge, it is used only when the river is at a high stage. North of the bridge is a high mountain, visible from a long distance to the southward, and identified as "The Steeples" of Captain Blackiston. Bull River.

Joseph's Prairie

Near the mouth of Wild Horse Creek, a ferry has been established across the Kootanie, and nine miles south-westward from it is Joseph's Prairie, where, for many years, Mr. Galbraith has, with the help of irrigation, raised excellent crops. The country between the Kootanie and Joseph's Prairie is undulating or hilly, partly wooded, and with occasional small projections of slaty Cambrian rocks. It forms an excellent cattle range, and in this connection it may be stated that the entire valley, from the forty-ninth parallel to beyond the Lower Columbia Lake, affords much excellent bunch-grass pasturage, and is well adapted for the support of a considerable number of cattle and horses.

Cattle country.

Outlines of formations.

Owing to forest fires in the neighboring mountains, and the consequent dense and persistent smoke, little was seen of the mountains forming the eastern border of this great valley, between the forty-ninth parallel and Wild Horse Creek, and the outline of the western edge of the limestone series is shown on the map with approximate accuracy only. The greater part of the valley is, however, without doubt, underlain by Cambrian slates and quartzites of the usual character, and Mr. Bauerman's previous observations show that these rocks also characterize, for a long distance, the mountains to the west of the valley near the forty-ninth parallel.*

Rocks near Elk River.

These rocks appear to lie in a series of wide undulations, generally at rather low angles. Near the mouth of the Elk, some exposures occur of greenish and grey fine-grained quartzites, precisely resembling those previously described as the Elk River bridge beds (p. 78 B). At this place, some purplish beds also appear, in which small pseudomorphous impressions of salt crystals (see p. 55 B) were observed, together with ripple-marked surfaces. Rocks of the same general character are seen in a few places north of the Elk River, but as no connected section can be offered, it is considered unnecessary here to describe them in detail.

Limestone area

On the lower part of the Bull River, near the banks of the Kootanie to the south of it, and elsewhere in this vicinity, rocks of the limestone series occur. The area affording these exposures, is outlined in a general way on the map, and is supposed to be bounded to the east by an extensive fault, which must run near the base of the mountains. The limestone is grey in colour, lies generally at rather low angles, (not exceeding 30° so far as observed), and resembles that forming the upper portion of the Devono-Carboniferous on Crow Nest Lake, in the abundance of crinoidal fragments, though no other fossils were seen in it. North of the Bull River, near the trail which leads to the bridge,

* See Report of Progress, 1882-84, p. 25 B.

and not far from the base of the mountains, a low, isolated hill was found to be composed of a remarkable crystalline rock, which is evidently intrusive. It is chiefly composed of well-formed, orthoclase felspar crystals, which are pinkish in colour, and, in some cases, nearly an inch in length. The rock is rather porous, owing to the decomposition which it has suffered, and its jointage-planes are coated with rusty incrustations and micaceous hæmatite. It may be regarded as a variety of quartz-porphyry in which the quartz is, however, observable under the microscope only. As loose pieces of a similar material were found in Elk River, it is possible that other similar intrusions occur elsewhere in this neighborhood. Quartz-porphyry.

Near the base of The Steeples, and at the bridge over Bull River, are numerous exposures of quartzites, of greenish and brownish colours, passing into grey tints and interbedded with, and merging into blackish argillites and slaty rocks. Some layers become conglomeritic, the pebbles being composed of a black, somewhat silky schist. The dips are in general eastward, at rather high angles, though locally disturbed. The rocks being on the strike of those on the Hughes Range, may be taken as typical of those composing it. A number of strongly marked jointage-planes, which run parallel to the direction of the base of the range, with high dips to the westward, may be connected with the supposed great fault previously mentioned. Small quartz veins are numerous, and become rusty and porous on weathering, from the removal of dolomitic matter. They were observed to include also little segregations of iron and copper pyrites. Gold has been obtained in paying quantity on Bull River, near this place, but only at very low stages of the water. Near the mouth of the river, we obtained numerous 'colours' by washing the gravel of the banks. A few 'colours' to the pan were also found on Sand Creek. On Bull River, near the bridge, loose boulders occur, of a fine-grained, granular hæmatite, seamed throughout with green and blue carbonates of copper. On assay it proved, however, to contain neither gold nor silver (see p. 26 M). Rocks on Bull River. Veins. Gold.

The drift material observed in the Kootanie Valley, south of Wild Horse Creek, is chiefly of the ordinary Cambrian rocks, or of limestone. Besides these, however, pebbles of whitish, granitoid rocks were occasionally seen. Such rocks do not occur in the Rocky Mountains, and it is probable that these pebbles have been derived from the Purcell or Selkirk ranges, on the west. Pieces of lignite were seen in the gravel of Sand Creek, and a large fragment of foliated lignite was picked up on Bull River. The occurrence of this material appears to afford proof that Tertiary rocks, resembling those of the Flat-head, occur also in the wide valley of the Kootanie in this vicinity. The quantity of superficial material, however, renders it impossible to define this area, even approximately. Drift in Kootanie Valley. Probable Tertiary area.

Wild Horse Creek.

Wild Horse Creek, named Skirmish River on Palliser's map, has been, from the first, the gold-mining centre of the Kootanie district. Its auriferous character was discovered in 1864, and it was this discovery which first drew the attention of miners to the Kootanie country. Since 1864, placer mining has been continuously carried on, and the total value of the gold obtained is probably not much less than $500,000. From 1878 to 1885 the returns show a yield of $188,380. Where it reaches the Kootanie, Wild Horse Creek is, at low-water, a swift stream of about forty feet in width by one in depth. For about two miles from its mouth, it occupies a deep trough, which it has excavated in the silty and gravelly terrace-deposits of the main valley, and this part of its course is now much obstructed by tailings washed down from the mines above. Further up, the valley is narrower, with steep banks, which show many exposures of rock, and high and very steep mountains rise above it on both sides.

Placer gold mines.

Character of the mines.

The portion of the valley in which successful mining operations have been carried on, is about two miles only in length, and extends north-eastward into the Hughes Range, from the base of the mountain slopes. The 'bed rock' was reached at no great depth below the bed of the present stream, in this part of its course, and was found to yield much coarse gold; nuggets valued at $100, being frequently obtained. Endeavours to reach the channel of the old river further down, have so far been unsuccessful. A sum of $10,000 was expended in one such attempt, but the surface of the rock, when reached, was found to slope steeply down beneath the detrital deposits of the great Kootanie depression, and work was abandoned. The mining has, consequently, now, for some years, been confined to the "side-ground," consisting of narrow, terrace-flats, which border the stream, and irregular sheets of gravel and detrital matter which lie upon the slopes. Of late years, the mining has fallen almost altogether into the hands of the Chinese. There is still much of this 'side-hill ground,' and, though portions of it are probably too poor to be worked in the manner employed hitherto, it is probable that the whole might be utilized with advantage with the aid of suitable hydraulic appliances.

The gold obtained is valued at $18·25 per ounce. No platinum, silver or galena have been found with the gold in the sluice boxes, magnetic iron sand being its usual associate.

Origin of the gold.

The gold of Wild Horse Creek is evidently of local origin, but no gold-bearing quartz has yet been observed in its valley. The rocks in the Hughes Range, to the south of Wild Horse Creek, dip north-eastward, at angles averaging about 40°, and the range presents a steep escarpment-like front to the Kootanie. They consist, so far as observed, of quartzites, blackish and greenish schistose-

rocks and argillites, with some compact greenstones, which probably occur as interbedded masses. Rocks of the same character are represented on Wild Horse Creek, but the strike there changes to a nearly north-and-south bearing, and the beds are nearly vertical. In ascending the valley, the first rocks met with, at the base of the range, are greenish-grey, rough and rather massive schists. Following these, are blackish, greenish and grey, rather silvery schistose rocks, not distinctly micaceous, but probably owing their lustrous appearance to talc or chlorite. They are sometimes essentially argillities, but very often, on cross-fracture, prove to be fine quartzites. Cleavage is in some places distinctly marked, but its strike is parallel to that of the bedding. These blackish and silvery schistose rocks run with the valley in its auriferous portion, and are probably the source of the gold. They are traversed by very numerous seams and veins of quartz, and bands of the schist have become in places more or less completely silicified throughout; the whole evidencing much segregative and probably hydrothermal action. No large or regular quartz veins were, however, observed. The small veins generally contain spathic iron and dolomite, as well as quartz, and were noticed also to hold iron- and copper-pyrites, and minute specks of galena. They resemble much those seen near Bull River bridge (p. 151 B). The gold now found concentrated in the bottom of the valley has apparently been derived from the wearing down of a great mass of these schistose rocks with their contained quartz veins, none of which may be individually of such size as to pay for working. It is by no means improbable, however, that persistent veins of workable dimensions will be found in this rich little district, and now that the placer deposits have so much deteriorated in value, attention should be turned in that direction.

Rocks on Wild Horse Creek.

Veins.

From Wild Horse Creek northward to the point at which the Kootanie enters this wide valley, no features occur requiring lengthened notice. The wide trough in which the river flows shows flats, some of which are cultivable, and others, which are evidently flooded at times of high water, would afford much good hay. This axial trough is bordered by low terraces, which are often of considerable width, and produce good grass. The valley is more generally wooded than in its southern portion, but is seldom thickly forested till the bases of the mountains are approached. The Lussier River, a stream about equal in size to Wild Horse Creek, is the only considerable tributary from the east, rendering it evident that the Bull River must unwater the greater part of the country hehind the Hughes Range. This range, north of Wild Horse Creek, is less regular in form, and shows more prominent peaks than to the south, but appears through-

Kootanie Valley north of Wild Horse.

out to be composed of similar rocks. North of Lussier River, the limestones again form the range bordering the valley. Partial views obtained (when the smoky character of the atmosphere happened to be abated by showers) of the mountains on the west side of the valley, showed these to be rounded in form, and not very high, and it is probable that the greater part of the Purcell Range is formed of similar Cambrian rocks. The peculiar relations of the Kootanie to the Upper Columbia Lake have already been noticed (p. 29 B). The white, silty deposits continue to form the basis of most of the terraces along the valley, and were seen near the head of the Upper Columbia Lake, at a height of about 300 feet above it, or 3,000 feet above sea-level.

Upper Columbia Lake. The Upper Columbia Lake is about 2,700 feet above sea-level, and, as determined barometrically, is a little less than forty feet *lower* than the nearest part of the Kootanie River, in the same valley. Its banks are formed by terraces, about one hundred feet in height, of the white silt deposits. The main valley has been blocked at the head of the lake by the delta formed by the Kootanie, and possibly also in part by that of Findlay Creek, on the opposite side. The lake is similarly held in at its lower end by the delta deposit of Dutch Creek. The trail follows the east side of the lake and runs part of the way along fine, grassy slopes, which lie between the lake and the base of the mountains. Copious springs issue in several places along this slope, and deposit considerable quantities of calcareous matter.

Hot spring. Near the first stream from the east, beyond the lower end of the lake, and about two miles distant from it, is a copious hot spring. It is about half a mile east of the trail, on the slope of a hill, and issues in several places from the summit and sides of a rounded, calcareous knoll formed by its deposit. The main efflux, at the summit of the knoll, has produced a raised basin, which within measures about eight by four feet, and is two feet deep, forming an admirable natural bath. The discharge at this place is probably not less than twenty gallons per minute, and the temperature of the water at this (the hottest) point, was found to be 112° F. There is no discharge of gas, but the water has a slight styptic saline taste. The brook immediately south of, and opposite the spring, has formed a miniature cañon by cutting for a considerable distance, through calcareous tufa, which in superposed flaggy layers, forms a thick deposit, overlying the gravelly material of the higher terraces. Sir George Simpson, who visited this spring in 1841, gives the following notes respecting it.—

Sir George Simpson's remarks. "Near our encampment, we observed that the stones in the bed of a little stream were covered with a yellow crust. Before starting for the day, Berland conducted us to three hot springs, about three miles distant, which doubtless caused the phenomenon in question. The

waters tasted slightly of alum, and appeared to contain a little magnesia; and, though we neglected to take our thermometer with us, yet, on returning to camp, we estimated the three temperatures respectively at about ninety, a hundred and a hundred and twenty degrees. Two winters back, Berland, while suffering from a severe illness, made a bathing-place of these springs; and he either actually was, or believed that he was, benefited by them."*

The Lower Columbia Lake is separated from the Upper by about seven miles of marshy valley, through which the river winds. Its general appearance is similar to that of the Upper Lake. The general direction of the valley, with its bordering ranges, here suffers a marked change in trend, turning more to the westward, in correspondence with the similar change in direction found on the east side of the range at the Highwood Gap, which is in the same latitude. Lower Columbia Lake.

From the lakes to the Kicking Horse River, the character of the valley is nearly everywhere the same. The depression in the centre of the valley, in which the Columbia flows, is a mile or more in width, and is occupied by a series of swamps and lagoons among which the river pursues a tortuous course, with a comparatively sluggish current. This axial depression is bordered on both sides by terraces, of variable width, which become more densely and uniformly wooded northward, and are broken by the deep valleys of numerous small tributary streams. On the west side, the valley for the greater part of its length, spreads widely, the surface rising gradually but irregularly in terraces and low ridges toward the base of the Selkirk Mountains, Long Mountain and high, rocky ridges to the north of it, however, narrow the valley for a distance of about twenty-five miles, being interposed between the river and the Selkirk Mountains. Columbia Valley.

The limestone range, which borders the valley continuously on the east, is steep, rough and bare, but seldom includes mountains exceeding 8,000 feet in height, till it approaches the Kicking Horse. The streams joining the river from this side, though numerous, are small, and drain inconsiderable areas in the Stanford, Brisco and Beaver-foot ranges. The outer range of high mountains in the Selkirks is usually distant six or seven miles from the river, and its lower slopes are all densely wooded. This range is cut by a number of important valleys, which carry tributary rivers of considerable size to the Columbia. The forms of many of the mountain masses in the Selkirks are fine, and the height of some of them is considerably over 9,000 feet above the sea-level. These mountains are shown on the map, as approximately fixed by bearings and sketches from the east side of Bordering mountain ranges.

* Narrative of an Overland Journey Round the World. Vol. I., p. 128.

the valley. Their delineation must, therefore, be accepted as approximate only, and no facts bearing on their geological structure were obtained.

Rocks found along Columbia Valley.

The limestone rocks of the mountains on the east side of the Columbia valley, though often much disturbed, show a general tendency to eastward or north-eastward dips, and along the border of the upper part of the Upper Columbia Lake, soft, grey, slaty argillites, with some layers of dolomitic limestone, appear at high angles, unconformably underlying the great limestone series. These rocks are referred to the Cambrian, but the few fragments of trilobites found in them cannot be determined even generically. Between the Columbia Lakes, some yellowish-weathering, coarse sandstones, with conglomeritic layers, charged with quartz pebbles, are also referred to this formation, but doubtfully. Thence, for many miles northward, the rocks of the limestone series appear in a number of places along the edge of the valley, and probably underlie its whole width. They seem also to form Long Mountain, the beds in which are nearly horizontal. Twenty-two miles south-east of the mouth of the Kicking Horse, Cambrian, slaty rocks, precisely resembling those above described, re-appear, and are seen in a number of places all the way to the Kicking Horse. They evidently form a narrow, continuous band, along the line of the Beaver-foot Range. Their uniformity in appearance is noteworthy, as also their exact resemblance to those immediately underlying the limestones on the Kicking Horse River, at several places between its mouth and the south-east end of Mount Hunter. On the slopes of the Beaver-foot Range, above these rocks, very massive beds of white or yellowish quartzite are associated with the limestone series, and these are provisionally included with the limestones under the blue colour on the map.

Glaciation and drift deposits.

The occurrence of large, loose blocks of this quartzite rock, many miles south of its outcrops, along the Columbia Valley, together with distinct glaciation in the same direction, seen on one or two surfaces of limestone, show, pretty clearly, that the ice which must have occupied the valley during the glacial period, moved southward. The white silts, found so extensively developed in the southern part of this great valley, also continue in this northern portion, but toward the mouth of the Kicking Horse, become gradually less characteristic in appearance, changing to a yellower shade of colour. They are also not so uniformly fine in texture, and are more than elsewhere mingled with gravelly intercalations. This change appears to afford additional evidence of the fact that thew hole valley, at the time of the formation of the terrace-deposits, drained to the south. Facts showing that its drainage followed the same direction during the formation of the still later axial trough, have already been cited (p. 31 B).

No fossils sufficiently well preserved to determine the age of the rocks, were collected by us in any part of the Columbia Valley, but Prof. A. P. Coleman of Victoria University, Cobourg, was so fortunate as to obtain a few fossils from the rocks of the south-west slope of the Beaver-foot Range, which he submitted to Mr. J. F. Whiteaves for determination. These included *Halysites catenulatus*, and *Favosites Gothlandicus*, with an *Orthis*, a *Rhynchonella*, and some crinoidal and cystidian columns, indicating a Silurian age. The first-mentioned species was collected in limestone which passed beneath quartzites probably identical with those above described. It is therefore probable that in this part of the mountains a considerable series of beds, intermediate in age between those of the Cambrian and Devonian, are developed, and the result of Mr. McConnell's work, on the Kicking Horse, will be awaited with interest in this connection. **Fossils and age of rocks.**

The auriferous character of several of the streams on the west side of the Columbia, in this part of its length, is referred to on a subsequent page.

Recapitulation of Geological Section.

Under this heading, it is intended to review, in brief terms, the features of the various members of the general section met with in this district of the Rocky Mountains, to compare the several local sections, and to note such other general facts as may be of importance.

Of the rocks referred to throughout this report as Cambrian, no complete general section can be offered. So far as this district is concerned, they form the basal formation, and it will probably be necessary to seek their actually lowest beds in the Purcell or Selkirk ranges, in which it is probable that they occur in conjunction with still older crystalline rocks. The component beds of the great Cambrian series are, in the main, quartzites and quartzitic shales, passing into argillites, and occasionally including limestone or more or less calcareous or dolomitic materials, and conglomerates. Sheets of contemporaneous trap also occur, probably at several horizons. The colours of these beds are extremely varied, and though, as a rule, considerably indurated, they seldom show traces of metamorphism resulting in the production of crystalline minerals. **Cambrian.**

The most instructive section obtained of a portion of the Cambrian formation, is that found near Waterton Lake, and in the eastern part of the South Kootanie Pass. This embraces a thickness of about 3,000 feet, and is detailed on p. 39 B. It is regarded as including a portion of the middle part of the formation as developed in this district, but somewhat careful search has failed to lead to the discovery of fossils in **Sections near Waterton Lake.**

it, and its constituent sub-series have not been clearly recognized in other parts of the region. This latter fact need not be supposed to indicate that the corresponding portion of the formation is elsewhere absent, but it is believed to arise from a variability in the composition of the series in different parts of the field. The rocks of the limestone series here rest with distinct unconformity on the eroded beds of the Cambrian.

Thickness.

Between the eastern summit of the South Kootanie Pass and the Flat-head River, the minimum estimated thickness of the outcropping Cambrian beds is 11,000 feet, but the section includes neither the summit nor the base of the series. Other sections show a probable thickness of over 5,000 feet for a part of the series, but none were found in which its whole volume could be ascertained.

Lithological character.

Throughout all this region of the Rocky Mountains, the general appearance and composition of the Cambrian is similar, but some points of difference may be observed as between its southern and northern portions, and it is believed that an upper part of the formation is extensively represented in the north-western half of the district, which is either entirely wanting or but seldom preserved in the south-eastern. The limestone, 200 feet in thickness, forming series B, in the sections near Waterton Lake, was not elsewhere recognized, and the massive, fine-grained, greenish and grey quartzites, referred to as the Elk River bridge beds (p. 78 B), found at several widely separated localities in the southern part of the district, were seen seldom, if at all, to the northward. To the south, also, the red beds, more fully mentioned later, are not nearly so characteristic or important. In the north-western part of the region, fine-grained argillaceous shales and slates, which become in some places glossy or silky in aspect from the incipient development of crystalline minerals, and vary in colour from black to pale grey or yellowish, are much more prominent, while the conglomerate beds, with quartz pebbles, are there also most frequently found. It is, further, in this north-western part of the district, that the few fossils which have been collected in this great quartzite or Cambrian series, were obtained. These occur within two or three thousand feet of the top of the formation as there developed, and, as already stated, represent a Middle Cambrian horizon, while no vestige of a fossil has yet been obtained from the rocks to the southward.

Conditions of deposit.

On the western part of the South Kootanie Pass, in connection with red beds, which include both sandstones or quartzites and shales, ripple-marked surfaces, surfaces broken by mud-cracks, and beds covered by pseudomorphs of salt-crystals, were observed; these evidencing not only shallow-water conditions, but showing that areas of sea-water, cut off from the ocean, had there become by evaporation

saturated solutions of sea-salt. Similar facts were noted near the lower part of the Elk River, and from their association with the red beds (an association repeated in the Triassic rocks of the same region) it may be safely assumed that the red coloration is connected in its origin with similar conditions. Such red beds are there extensively developed, and are believed to occur at two or more horizons in the series, and it is not improbable that the deposition of these presumably lower beds of the Cambrian, occurred in a basin, which was often, if not continuously, separated from the main ocean.

Pseudomorphs of salt crystals.

The pseudomorphous impressions of salt-crystals above referred to, are quite distinct in appearance, and easily distinguished from pseudomorphs of crystals of iron pyrites. They have been filled by clayey matter, while the rocks were still in a soft state, and have generally been much flattened by the subsequent consolidation of the material by pressure. It therefore appears necessary, to suppose that this part of the Cambrian was converted, not long after its deposition, into a land area, so as to allow the percolation through it of fresh surface waters. It is even possible that this occurred before the formation of the supposed later Cambrian rocks of the northern part of the region.

Conglomerates.

The conglomerates above alluded to were seen for the most part in connection with the Cambrian anticlinal of the upper portion of the Bow Valley. They are characterized by pebbles of milky or semi-transparent quartz, together with pieces similar in size of fresh-looking whitish felspar, and the matrix contains abundance of pale mica. These constituents have evidently been derived from some not far distant exposures of coarse granitic or gneissic rocks, Fragments are also found of dark, lustrous schist. Rocks of the character of those largely developed on Shuswap Lake and in the Gold Range would afford such material.*

Cambrian of Wasatch.

The Cambrian of this part of the Rocky Mountains resembles that of the Wasatch Mountains in Utah, in the fact that with the exception of the Middle Cambrian fossils near its summit, it is entirely destitute of traces of life. Its general lithological character is also similar. The Cambrian of the Wasatch is described by Messrs. Hague & Emmons as "a body of quartzites more or less argillaceous, having some fine-grained mica-schists in its upper portion, and, near the base of the part exposed, a bed of some 800 feet of dark-blue, almost black, finely laminated argillites. Its thickness, as estimated from the distances between outcrops and the average dip, cannot be less than 12,000 feet."†

* See Report of Progress, 1877-78, p. 96 B.

† Geological Exploration of the Fortieth Parallel, Vol. II., p. 366.

Cambrian of Grand Canyon.

The lithological resemblance is, however, in some important particulars, even closer as between the Cambrian rocks of this part of the mountains, and those of the Chuar and Grand Cañon groups of the Colorado Cañon in Arizona, as described by Mr. Walcott.* The occurrence of thick beds of parti-coloured shales, the abundance of ripple-marks and mud-cracks throughout, and especially the evidence (in the Grand Cañon group) of contemporaneous volcanic activity, in the form of interbedded greenstones, constitute points of identity with the series here described.

Absence of life.

In a paper received while this report is going through the press,† Mr. Walcott refers to the absence of the Lower Cambrian fauna in the western part of the continent, and provisionally refers it to a land barrier, supposed by him to have existed at that time between the eastern and western portions of the Continental area. It is perhaps worth noting the fact, that the body of water in which the lower portion of the rocks here described were deposited, was a basin separated from the ocean, and, occasionally, if not continuously, in the condition of a saturated brine, may in itself explain the absence of life of any kind, at least in this particular region.

The facts at present available do not warrant any definite statement as to the character of the beds which appear to occupy a position between the Cambrian and the Devono-Carboniferous limestone series. It is evident that strata filling at least a part of this interval, occur in the north-western portion of the district here described, and their investigation is at present in progress by Mr. McConnell.

Limestone series.

The great limestone series of the mountains is referable, in a general way, to the Devonian and Carboniferous periods, and characteristic fossils have now been collected from many parts of it. Its thickness and development is probably irregular, and dependent on the contour of the older rock-surface on which it rests uncomformably. Near the eastern end of the South Kootanie Pass, its volume was estimated at 1,000 feet (p. 39 B), while on the same pass, near Mount Yarrell, its minimum thickness is about 4,000 feet (p. 50 B). On the Crow Nest Lake there is an apparent thickness of 9,610 feet, but subsequent investigation renders it probable that this is due to folding, and that the actual exposed thickness is 3,575 feet, the base of the formation not being seen (p. 72 B). In this section and elsewhere, between 1,000 and 2,000 feet of the upper portion of the limestone is highly crinoidal in character.

A prolonged period of quiet marine deposition is indicated by this great body of limestone.

* American Journal of Science, Vol. XXVI., p. 437.

† Ibid, Vol. XXXII., p. 138.

Overlying, and blending with the highest beds of this limestone series is a thickness of several hundred feet of rather massive calcareous sandstones, which weather to reddish or yellowish tints. These were well seen near the Crow Nest Lake (p. 73 B). On the South Kootanie Pass, west of the Flat-head (p. 54 B), at the west entrance to the Gap of the North Fork of the Old Man (p. 80 B). Near the east end of the White Man's Pass (p. 113 B), on the Cascade River (p. 143 B) and elsewhere. In these beds, or in the limestones near this horizon, the greater part of the distinctly Carboniferous forms were found. On the Bow River, near the mouth of Red Earth Creek, and on the Elbow, forming the eastern edge of the isolated limestone area in the foot-hills (p. 104 B) a considerable thickness of black, flaggy, highly calcareous shales was observed occupying a similar position at the top of the limestone series, and possibly representing a local difference in character of sedimentation on the same horizon. Highest beds of limestone series.

South of the line of the Crow Nest Pass, the limestone series is conformably overlain by rocks which are referred to the Triassic or Permo-Triassic. In the vicinity of the South Kootanie Pass, an interbedded, amygdaloidal diabase everywhere occurs at the base of the Triassic rocks. This, though classified under a separate letter (E) in the general section of that region (p. 39 B), is now known from the occurrence of a similar bed (if not the extension of the same one) among the distinctively Triassic rocks of the summit of the North Kootanie Pass (p. 60 B) to be more properly ranked as a member of that series. The trap flow has a thickness of fifty to one hundred feet, and is overlain near the South Kootanie Pass by red beds and fawn-coloured magnesian sandstones, 600 feet in thickness. Near the North Kootanie summit it forms part of a similar series of alternating, flaggy, magnesian sandstones, and red sandstones and shales, 2,000 feet in thickness (p. 60 B). In connection with the red beds, ripple-marked surfaces, mud-cracks and impressions of salt-crystals occur, the whole indicating, as the conditions of deposition of the rocks, those of a basin cut off from the main ocean. Triassic.

With the single doubtful exception of certain red beds, seen from a distance, near the summit of the White Man's Pass (p. 115 B), these Triassic rocks are entirely confined to the district south of the Crow Nest Pass, and, as elsewhere more fully shown,* we find here probably the northern limit of a great Triassic mediterranean sea, which extended far to the southward in the western part of the present Continental area. Distribution.

* Trans. Royal Soc. Canada, Vol. I., Sect. IV., p. 143.

Precise age doubtful.

The entire absence of fossils makes it impossible to decide the age of these beds on palæontological grounds, but their stratigraphical position and similarity to the Triassic of regions to the south, render it nearly certain that they are, in part at least, properly referred to that formation. The gradual character of the passage from the upper beds of the limestone series (broken only by the casual intercalation of trap), tends to show that part of the lower portion of the series may not improbably represent the Permian period.

Cretaceous.

The rocks of the Cretaceous, are the next in ascending order known in this region. Over the area of the great plains, both in the United States and Canada, and in the Rocky Mountain region south of this district, the lowest rocks of the Cretaceous series developed, are those of the Dakota, of Middle Cretaceous age. In the vicinity of the West Coast, Lower Cretaceous rocks are found, and in this part of the mountains we appear to enter upon the edge of the area of deposit of the Lower Cretaceous, the beds here named the Kootanie series occupying

Kootanie series.

that horizon. The geological horizon of the Kootanie series is determined by its position relatively to the higher members of the Cretaceous series, and by the fossil plants which it has yielded, which

Fossils.

are enumerated on former pages. No fossil remains but those of plants have been found, with the exception of a broken fragment of a mollusc, which is pretty evidently a *Goniobasis*, from the plant beds of Coal Creek, and part of the guard of a belemnite from the beds of the Cascade basin. Though the Kootanie series is here throughout spoken of as a portion of the Cretaceous, its fossil flora shows, according to Sir J. W. Dawson, points of affinity with the Jurassic of some other regions. The plants "consist of ferns, cycads and conifers, some of them identical with, or closely related to, those of the Jurassic of the Amur country in Siberia, and others similarly related to the Lower Cretaceous of Greenland, as these floras have been described by Heer. This group, undoubtedly represents the flora of the Lowest Cretaceous, which has not hitherto been recognized in Western America."* The localities from which plants of this stage have already been collected, in the district here described, are comprised within an area about a hundred and forty miles in length by forty in breadth, but occur in several now distinct Cretaceous infolds. That the series characterized by these plants is a wide-spread and important one, is shown by the fact that one of the species (*Pinus Suskwaensis*) had previously been found on Suskwa River, in Northern British Columbia, at a distance of 580 miles north-west of the most northern locality here referred to.

* Trans. Royal Soc. Canada, Vol. III., Sect. IV.

Conditions of deposition of Triassic and Cretaceous.

The relation of the lowest beds of the Kootanie series, or base of the Cretaceous, to the Triassic beds of the southern part of the district, has not been observed, but northward, in a number of places, these rocks have been found to rest with an appearance of conformity on the calcareous sandstones, previously described as forming the summit of the limestone series. The occurrence of conglomerates in association with the Kootanie series, largely composed of rolled chert pebbles from the limestones, and containing, also, fragments of limestone, evidences, however, that the limestone series was fully hardened, and that segregative action had had time to produce its characteristic silicious concretions before the beds of Kootanie age were formed. We have already seen, that it is probable that the Triassic red beds never extended to the north of the southern part of this portion of the Rocky Mountains. If they did so, they must have been removed by denudation before the deposit of the first Cretaceous beds, and it is highly improbable that this should have occurred in such a way as to leave the calcareous sandstones above mentioned, so generally at the actual surface, at the moment when the deposition of the Cretaceous commenced. The denudation necessary for the removal of the Triassic beds, would probably have produced a rough, irregular, worn surface, on which the Kootanie beds would be found to rest. The fact being otherwise would appear to show, that deposition ceased in the northern part of the area during the Triassic, in consequence of the gentle upraising of this northern region to form a wide area of low, flat land, not likely to be affected by severe denudation. It is possible that this land was actually that which separated the enclosed Triassic mediterranean of the south, from the truly marine Triassic area of the *Monotis* beds, developed in the Peace River region and elsewhere to the north. At a later date flexure occurred, the waters again invaded the land area by hollows and depressions, in which the lowest beds of the Kootanie group were at once laid down; while intervening anticlinals stood out as rocky islands and more or less extensive land areas, the wearing away of which supplied the materials for the conglomerates and sandstones of the Kootanie and later Cretaceous beds.

Constitution of Cretaceous series.

No complete section can yet be given of the Cretaceous rocks of the mountain region, nor of those of the adjacent foot-hills, which, doubtless, at one time formed a continuous sheet with them; and on the accompanying map it has been deemed advisable to give one colour not only to the various sub-divisions of the Cretaceous, but also to such Laramie rocks as occur within the area. Two horizons appear, however, to be fixed with considerable definiteness in the lower part of the Cretaceous of the mountains,—that of the most important and persist-

ent coal-seams, and that of the volcanic intercalation. The first of is fixed in part, by the similarity of appearance and character of the coals and beds near them, but chiefly by the very similar group of fossil plants, which is found in association with these coal seams.

Coal-bearing horizon.

The coal-bearing horizon found in two places on the eastern part of the North Kootanie Pass (pp. 58 B., 59 B), at the western summit of the same pass (p. 64 B), on the Crow Nest Pass (p. 69 B), and at two places on the North-west Branch of the North Fork of the Old Man (pp. 87 B., 88 B), together with that of the chief coal seams of the Cascade trough, both on the Bow and Cascade Rivers, and on the Red Deer (pp. 126 B., 146 B), the coals of Fording River (p. 109 B), and probably of the Green Hills, near the Elk River (p. 110 B), is believed to be nearly, if not quite identical. In the adjacent foot-hills the coal met with near the mountains on the North Fork of the Old Man is probably also on the same geological plane.*

Thickness of Cretaceous series.

The thickness of rocks of the Kootanie series below this coal-bearing horizon was estimated on the Crow Nest Pass, and near the west summit of the North Kootanie Pass at about 7,000 feet, which may be taken as a minimum estimate of the greatest observed development of this part of the series. The beds are chiefly shales and sandstones of very varied texture and appearance.

The volcanic ash beds and agglomerates of the Cretaceous, in this region, are evidently due to a local eruption, which had its centre in the latitude of the Crow Nest Pass. These volcanic rocks have, however, been traced north and south from this point over a total length of forty-five miles, and may probably have at one time had as great an extension east-and-west, though this has subsequently been dimished by the folding together of the beds. The volume of strata between the coal-bearing horizon and base of the volcanic rocks on the Crow Nest Pass, was estimated approximately at 3,350 feet, on the South Kootanie Pass at 2,400. The mean of these approximations, 2,750 feet, may for the present be adopted as a probable result. The volcanic rocks themselves, on the Crow Nest Pass, where they attain their maximum, have a volume of about 2,200 feet, but thin out very rapidly to the north and south.

Summit of Kootanie group

The summit of the Kootanie series is not yet precisely defined, but is situated betweeen the apparently-constant coal-bearing horizon and the base of the volcanic beds, as, on the North-west Branch of the North Fork (p. 88 B), fossil plants, believed to represent the horizon of the Dakota, are found a few hundred feet below these volcanic beds. This observation would make the horizon of the volcanic rocks them-

* See Report of Progress, 1882-84, p. 103 C.

selves as nearly as possible identical with that of those previously referred to (p. 69 B), as having been noted by Prof. Stevenson in Colorado. It is, therefore, not improbable that we find in these two very widely separated localities, traces of an epoch of volcanic activity in the Dakota period, which may yet prove to be important. Volcanic rocks are also largely developed in connection with the lower parts of the Cretaceous on the west coast of British Columbia.

Rocks of Kootanie series

The sections representing the upper part of the Cretaceous rocks of the mountains are, unfortunately, very unsatisfactory, the best being that of the North-west Branch just alluded to (p. 88 B). The volcanic beds are there followed by dark shales which afford a few fossils referred to the Benton group, and are estimated to attain a minimum thickness of 1,400 feet. Above these are sandstones and shales, generally of pale tints and possibly several hundred or a thousand feet in thickness, which are supposed to represent the Belly River series of the plains to the eastward. A concealed area beyond these, is presumed to be underlain by the Pierre shales, and still higher in the section are beds referable to the base of the Laramie, with characteristic fossils. The thickness of the Laramie at this place is indeterminate, but must be considerable.

Rocks of Cascade trough.

The section of the Cretaceous rocks of the Cascade trough, to the north, has not been referred to in the preceding paragraphs. Its distance from the localities here particularly described, and the entire absence of the volcanic intercalation, renders precise correlation at present impossible. The plants found in association with the principal coal horizon are, however, similar to those elsewhere observed in the same connection, and, as previous stated, it is not impossible that the thicker coal-seams occupy a similar horizon throughout. The chief coal-seams here hold a middle position in a section showing at least 0 feet of sandstones and shaly beds, and including numerous less important coal-seams. At 2,500 to 3,000 feet above the thickest coal-seams, are important beds of conglomerate, which are possibly on the same horizon as those of the summit beyond Marten Brook on the west part of the Crow Nest Pass, which were estimated to be at least 1,500 feet above the coals of Marten Brook. On the hypothesis that the principal coal-bearing horizon of the Cascade basin occupies the same position as that developed in the southern part of the district, the thickness of beds found above this plane in the Cascade basin, would appear to indicate that the upper members of the section there, may be referable to the Dakota group. None of the characteristic plants of that group have, however, so far been obtained from these rocks.

A provincial general representation of the Cretaceous beds of the

General section of Cretaceous.

mountains of this region, as compared with those of the plains to the east,* may be given as follows, in descending order:—

	Rocky Mountains.	FEET.	*Foot-hills and Plains.*	FEET.
Laramie.			Porcupine Hill beds	2,500
			Willow Creek beds	450
	St. Mary River beds (base)	[not known].	St. Mary River beds	2,800
Cretaceous.	Fox Hill and Pierre	["]	Fox Hill and Pierre	830
	Belly River series	["].	Belly River series	910
	Benton and (Niobrara ?)	1,400	"Lower Dark Shales"	800
	Volcanic rocks (greatest thickness).	2,200		
	Dakota and upper part of Kootanie series to coal-bearing horizon	2,750		
	Lower part of Kootanie series	7,000		
		13,350		8,290

Total volume.

Adding the estimated volumes of the series of the adjacent plains, down to and including the Belly River series, to those of the lower groups of the mountain area, we arrive, for the Cretaceous of the region, at a total maximum thickness of 20,840 feet. While there is yet no certainty that the whole of this vast series of beds was deposited in any one part of the region, no evidence of a contrary tendency is known, and so far as observation goes, the beds of the plains show a decided increase in thickness on their approach to the foot-hill and mountain area.

Circumstances of deposition.

With regard to the circumstances of deposition, in the area of the mountains here particularly described, the following statement may be made. Marine conditions appear in connection with parts of the Kootanie group, but it is evident, that while a great subsidence was in progress, sedimentation in general more than kept pace with it, leading to the frequent occurrence of tracts of land on which vegetation could flourish. This continued to be the case till the volcanic eruption which produced the ash and agglomerate beds occurred, and it is even probable, from the discovery of plant remains in them, (p. 57 B) that some of these beds were sub-aerial. The sea held a prolonged sway over the region during the deposition of the Benton shales with marine fossils, but it is not known whether fresh-water and terrestrial conditions supervened in this particular district during the prevalence of such conditions over the neighboring area of the plains in the Belly River period. The Pierre shales having been found in the adjacent foot-hills to hold marine fossils tends to show, that at the time of their depositions, marine conditions must have prevailed also over the area of the mountains. As in the adjacent foot-hills, the base of the Laramie consists of estuarine deposits.

* See Report of Progress, 1882-84, p. 112 c.

Of the character of the Miocene (?) beds, referred to in the descriptive portion of the report (p. 52 B), so little is known that nothing need be said of them here, except to note, that their area is apparently not extensive, and that they represent the first known renewal of sedimentation after the great period of mountain making, and a vast erosion, which left the surface much in the condition in which it now appears. They lie in one or more valleys and are probably the deposits of ancient fresh-water lakes, like those found in Miocene times in the Interior Plateau region of British Columbia. Miocene.

A number of facts connected with the glaciation of this part of the mountains, have been noted on previous pages of this report. The general features indicated by them add little to the sketch of the glacial phenomena for this region, given in a previous report.* All the valleys in the mountain area have evidently at one time been choked with ice to a great depth, and glaciers debouched from them into the foot-hill region to the eastward, while a great combined glacier with southward movement, seems to have filled the Columbia-Kootanie Valley on the west. Notwithstanding this, there appears to have been very little heavy ice action or transport of material in some portions of the range, as in the region above the head waters of the Old Man River. Glaciation.

It is also worth noting, that while boulders of eastern Laurentian rocks are found up to the very base of the range near the forty-ninth parallel (as described in the report just referred to), no fragment of rocks of this kind has been found in any part of the mountains proper.

One other point, which appears to be anomalous, and which I will at present not venture to endeavour to explain, is the occurrence of heavy glacial striation in a southward or south-eastward direction, on rock surfaces on the bank of the Jumping Pound River, about thirteen ~~rock~~ miles east of the base of the mountains, in a region of wide valleys and low foot-hills.

General Note on Economic Minerals.

The occurrence of the various minerals of economic value, has been fully described in connection with the localities in which they are found. It will, therefore, be necessary, in conclusion, merely to recapitulate the main facts. Distribution of Coals.

The Cretaceous rocks, coloured green on the map, are the coal-bearing series of the region, and coals have already been found in a number of places in each of the great basins represented. These basins, or troughs, are distinguished by name as the Crow Nest, Elk River,

* See Report of Progress, 1882-84, p. 139 C.

and Cascade River troughs respectively, for convenience of reference. Owing to the rough character of the country and the complication of the outcrops, it is certain that but few of the actual exposures of coal have yet been discovered, and that the number and extent of the seams as now known will be largely increased by future research. The adjacent foot-hills are also well supplied with excellent coals, as more fully described in the Report of Progress for 1882-84. Within the mountain area, many of the coal outcrops are in localities so remote and difficult of access, that their possible utility is considerably lessened. Others can be reached and used without much difficulty when required, and the anthracite of the Cascade basin is already being opened up. It is also probable that the discovery of metalliferous ores in various parts of the mountain region, will at a future date, cause the coals of places otherwise unimportant to be drawn upon for smelting purposes.

Reference to map. The principal known coal outcrops are numbered consecutively on the face of the accompanying general map, and references given to the pages on which they are described.

Character of coals. Within the mountain area, the coals so far examined occur chiefly in the Kootanie group, or lowest Cretaceous, and, with the single exception of those of the Cascade basin, they rank as bituminous coals. The anthracitic character of the coals of the Cascade basin does not even extend to the whole area of this Cretaceous infold, but is evidently due to exceptionally severe local alteration, as, on following the same beds northward to the Red Deer River, the contained fuels became coaking coals. Loose fragments of coal found in the upper part of Sheep Creek, in the northern extremity of the Crow Nest trough, show a tendency to become anthracite, but the beds were not found in place. The fuel most nearly approaching a lignite is that derived from the beds in Oyster Creek, which contains four per cent. of hygroscopic water.

Gold. The only part of the region which has obtained a recognized position as a gold-mining district, is Wild Horse Creek, described on p. 152 B, but nearly all the streams flowing into the Columbia-Kootanie Valley, are known to contain more or less alluvial gold, and on some of these, particularly those joining from the west, paying claims have been worked. The restricted character of the portion of Wild Horse Creek which has proved so richly auriferous, shows how easily similarly rich portions of other creeks may be passed over in this rough, mountainous country, and should be an incentive to the prospector to carefully examine all portions of the district which are based on the slaty zones of the Cambrian. No auriferous alluvial deposits have yet been found to the east of the watershed in the mountain region, and though the gravel bars of

numerous streams were examined by washing, not even 'colours' could be obtained on this slope. It is still possible, however, that paying placers will be found within some of the Cambrian areas there, and as worthy of examination, I may note, the Cambrian anticlinal of the upper Bow Valley, and its south-eastward continuation on the branches of Red Earth Creek.

Copper and lead ores occur in this part of the mountains in considerable abundance. Most of those which have been prospected are in the vicinity of the Bow and Kicking Horse rivers and near the Columbia-Kootanie Valley. It is probable that some of these deposits already known, will prove to be of a remunerative character, and that many others will be discovered. It should, however, be stated that so far as the analyses of these ores yet made can be accepted as an indication of their general composition, the quantity of gold or silver carried by them is inconsiderable. The connection of deposits of this character with certain igneous intrusive masses has already been referred to (p. 123 B). It may reasonably be expected that metalliferous veins will also be discovered within the area of the Cretaceous rocks of the foot-hills or those portions of the same rocks which occur in the mountains, where the strata are found locally to be considerably altered, the sandstones being in some cases converted into true quartzites. Should such deposits be found in connection with these rocks, they may prove to be quite different in character from those of the limestone and Cambrian series. Copper and lead

Stones suitable for building purposes, are present in great abundance in almost all parts of the mountains. Limestone well adapted for burning is also everywhere to be found, and outcrops along the line of railway between Canmore and Kananaskis stations may be utilized with advantage for the supply of Calgary and other points to the eastward. Though slaty rocks are abundant in the Cambrian, none were seen which in regularity of cleavage, and other characters, are suitable for building purposes, and, in any case, such deposits could be worked only near the line of railway. The marble of the upper part of the Cross River (p. 116 B) is of no economic importance, owing to the inaccessible character of that part of the region. The sodalite of the Ice River is adapted for use as an ornamental stone, and might be worked up into very pretty jewelry. Building stones, lime, etc.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA

ALFRED R. C. SELWYN, LL.D., F.R.S., F.G.S., DIRECTOR.

REPORT

ON THE

CYPRESS HILLS WOOD MOUNTAIN

AND

ADJACENT COUNTRY,

EMBRACING THAT PORTION OF THE DISTRICT OF ASSINIBOIA, LYING BETWEEN THE INTERNATIONAL BOUNDARY AND THE 51ST PARALLEL AND EXTENDING FROM LON. 106° TO LON. 110° 50'.

BY

R. G. McCONNELL, B.A.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.
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To ALFRED R. C. SELWYN, ESQ., LL.D., F.R.S., F.G.S.,

Director of the Geological and Natural History Survey of Canada.

SIR,—I have the honour to present herewith a report, accompanied by illustrative maps and sections, on the geology and general resources of the Cypress Hills, Wood Mountain, and adjacent territory, embracing part of the District of Assiniboia. It treats of the country lying immediately east of the Bow and Belly Rivers District previously reported on by Dr. G. M. Dawson, and forms the second of a series designed eventually to cover the whole North-west Territory.

I have the honour to be,

Sir,

Your obedient servant,

R. G. McCONNELL.

January, 1886.

NOTE.

All the elevations, with the exception of those along the Canadian Pacific Railway, which were obtained by instrumental levelling, are the result of aneroid barometer readings, corrected by comparison with the regular barometric observations kept at Medicine Hat and Qu'Appelle.

The bearings are always with reference to the true meridian.

The invertebrate fossils mentioned in the following report have in all cases been determined by Mr. J. F. Whiteaves.

REPORT

ON THE

CYPRESS HILLS WOOD MOUNTAIN

AND ADJACENT COUNTRY.

The following report treats of that portion of the district of Assiniboia lying between the international boundary and the 51st parallel, and extending from the third principal meridian to range VI. west of the fourth, or from longitude 106° W. of Greenwich to 110° 50'. It embraces an area of about 31,000 square miles, and is accompanied by a geological and topographical map of the same district. The northern part of the map has been reduced from the township plans of the surveys made by the Dominion Lands Department, the only changes made being in the shape and contour of the ridges and other elevations. These are so intimately connected with the geology in a country where the beds are almost horizontal, that they demanded special attention. The topography of the southern part of the district, as laid down on the map, has been obtained chiefly by odometer traverses made by myself in the summer of 1883 and by Mr. D. B. Dowling in the summer of 1884. The surveys of H.M. North American Boundary Commission, along the 49th parallel, have also been incorporated in this part of the map.

Region covered by report and map.

Data of the map.

The country in the immediate vicinity of the 49th parallel was examined and reported on by Dr. G. M. Dawson, in 1874, while connected with the Boundary Commission, but in regard to all the rest of the district, very little trustworthy geological information was available before the present exploration was undertaken. In fact, the only work done is included in a hasty trip made by Dr. Hector to the west end of the Cypress Hills, in 1859, and a few notes collected by Professor Hind in regard to the geology of the country near the Elbow of the South Saskatchewan; that point being the western limit of his work while in charge of the Assiniboine and Saskatchewan exploring

Previous explorations.

expedition in 1858. Dr. Bell also visited the Elbow and a few other places along the eastern edge of the district in 1874.

Time occupied by present exploration.

The present exploration has occupied the seasons of 1883 and 1884. But as a great part of the time has necessarily been spent in the collection of topographical details, it may easily be seen that the remainder was insufficient to enable me to delineate in more than a general way, the main geological features of so extensive an area. The present report, therefore, cannot pretend to be much more than preliminary in its scope.

Character of report.

Physical Features.

Elevations.

The district of which this report treats forms part of the third great prairie steppe. It has a general elevation in its eastern part, north of the main divide, of about 2,200 feet. Near the western limit of the map this increases to about 2,500 feet, though parts of the Cypress plateau rise over two thousand feet higher. It includes, besides an extensive area of prairie country, the Cypress Hills plateau, the western part of Wood Mountain, and a number of smaller plateaus intervening between these two. The Missouri Côteau crosses its north-eastern corner. This country lies so far from the mountains, that it has escaped being affected to any appreciable extent by the disturbing forces which have been so active there. No intrusive rocks are met with in any part of the district, and the beds are either horizontal, or are subject to dips of the easiest description, scarcely ever exceeding ten or fifteen feet to the mile. Consequently, all the main surface irregularities have been caused entirely by the varying degrees of resistance which different parts of the area have been able to offer to the denuding agents.

Absence of intrusive rocks.

Cause of surface irregularities.

Extent and character of plains.

Only two kinds of country are represented in the district (1) Plains, (2) Plateaus. There are three distinct plains separated by well-defined boundaries. The largest one lies to the north, and extends from the Cypress Hills plateau to the South Saskatchewan and beyond, and from the western limits of the map east to the Côteau. This plain is by no means uniform in character; while in some places almost perfectly level, in other parts it becomes boldly undulating and even hilly, and is further diversified by numerous extensive areas of drifting sand-hills. It slopes north-eastward to the South Saskatchewan, to the basin of which it belongs, though that river receives from it but scanty addition to its volume, as most of the streams flow into large lakes where their waters are evaporated. The second plain occupies the country between the Cypress Hills, the White Mud River plateau, and the boundary. Near the eastern end of the Cypress Hills it is almost cut in two by a spur which that plateau sends southward. The western

part of this plain is extremely barren. The soil is a stiff grey clay, studded with pebbles and boulders, and produces nothing but cactus, with here and there a blade of *Stipa*, or other drought-loving grass. Eastward, the clay is replaced by a more loamy soil, and the plain becomes better grassed. The third plain extends south and east from Old Wives' Lake, and occupies a basin-shaped depression between the Côteau, Wood Mountain, Pinto Horse Butte, and the Swift Current Creek plateau. It is much smaller than the others, and is drained by the numerous branches of Old Wives' Creek into Old Wives' Lakes. In the north-eastern corner of the map a small part of the second prairie steppe is included within the limits of the present report. All the plains mentioned are underlaid by rocks of Cretaceous age, but these seldom appear on the surface, being usually concealed by a covering of drift which is often upwards of 200 feet thick.

The plateaus are best developed in the southern and eastern part of the district. With one or two unimportant exceptions, they are all of Laramie or Miocene age. The existing Laramie plateaus represent a former much greater one, which must at one time have stretched at least, from the Bud Buttes to the present Laramie plateau of Wood Mountain, and covered the whole country between the Cypress Hills and the Côteau. This area has been worn away on the south by tributaries of the Missouri, and on the north by streams flowing into the Saskatchewan, or into the pre-glacial representatives of these streams, until it has assumed its present limited proportions. The work of demolition, though greatly checked, is still being carried on by the White Mud River, Swift Current Creek, and a few other smaller streams. The principal plateaus of the district are the Cypress Hills, Swift Current Creek plateau, the White Mud River plateau, Pinto Horse Butte, Wood Mountain, and part of the Côteau. A brief description of each of these will be given later on, but before proceeding to that part of the subject, a few words in regard to the capabilities of the district in general may not be out of place.

Age of plateaus.

Principal plateaus.

Until within the last few years, that portion of the territories covered by the present report was regarded as almost a desert, and was thought to be entirely unfitted for settlement. The results of the experimental farms instituted by the Canadian Pacific Railway Company last summer (1884), which were, almost without exception, eminently successful, have been instrumental in dissipating this idea in regard to a large proportion of the district. It nevertheless, remains true, that there are extensive tracts of country in this part of the North-west which are wholly worthless. The desolate and repulsive region south of the west end of the Cypress Hills can never be utilized for any purpose, while in the great plains lying north of these

Agricultural value of district.

Results of experimental farms.

hills, the area covered by bare drifting sand-hills amounts to an appreciable part of the whole. The plateaus, though no doubt valuable for pastoral purposes, are too high and cold for the growth of cereals, and the same thing holds good in regard to the Côteau and the hilly country associated with it.

The best part of the district undoubtedly lies to the north along the Saskatchewan. Commencing near the mouth of the Red Deer, extensive plains of level or slightly undulating country border this stream on the south, and extend all the way to within a few miles of Swift Current Creek. These plains are little, if at all inferior from an agricultural standpoint, to the best lands east of the Côteau. Among the other more important areas of good land, I may mention the plains lying a few miles west of the southern portion of Old Wives' Lakes, the plains around Reed Lake, and the country near Maple Creek. Taking the district generally, barely one-half, even under the most liberal estimate, could be classed as suitable for agricultural purposes; a large proportion of the remainder is however well fitted for stock-raising, the parts ranking highest in this respect being the northern slopes of Wood Mountain and the country in the vicinity of the Cypress Hills.

GENERAL DESCRIPTION OF THE DISTRICT.

The Cypress Hills.

Elevation and trend of Cypress Hills.

The Cypress Hills plateau forms the largest and most important member of a system of uplands which, though usually at wide intervals, are everywhere irregularly distributed over the plains. Commencing about 30 miles south of Medicine Hat, where it attains an elevation of 1,200 feet above the plains at its base, or about 2,700 feet above the level of the Saskatchewan at Medicine Hat, it extends eastward, though with gradually diminishing height, for a distance of eighty miles. It ends on its northern and western sides in a bold scarp, varying in heighth from 1,000 feet to about 500 feet. This escarpment does not end with the hills, but continues on in a direction a little north of east to Swift Current Creek. On the south, the plateau, west of Battle Creek rises from three to four hundred feet above the plains. East of that point, the hills, except for short distances, have no distinct edge, the plain rising up to the level of the plateau with a long easy slope. The surface of the Cypress Hills plateau, west of the Four-mile Coulée, is, except where cut by the deep cañon of Battle Creek, very smooth and even, and has a gentle slope eastward of about twelve feet to the mile. East of Four-mile Coulée it becomes more rolling and irregular.

Surface.

An important feature in the general outline of the plateau, and one which is of great assistance in the elucidation of its geology, is the number of coulées which cross it transversely. Two of these, viz: Medicine Lodge Coulée, and another valley at the east end of the hills, part of which is now occupied by a tributary of Swift Current Creek, must have been excavated in early post-glacial times, as the present grass-covered condition shows that the inconsiderable streams by which they are now occupied are doing very little erosive work. Each of these valleys is now occupied by two streams, one draining to the north and the other to the south. Near the centre of the hills a depression of about seven miles wide, and from three to four hundred feet deep, crosses from north to south. This hollow is called the "Gap," and is evidently of sub-aqueous origin, as it shows no indications of ever being the bed of a stream of any size. It lies immediately east of the unglaciated part of the hills and was probably produced by a current in the glacial sea, sweeping round that part of the plateau which remained unsubmerged. Transverse coulées. The "Gap." Origin of the "Gap."

The drainage of the hills is nearly all to the south and east, the principal streams concerned, being Battle Creek, and the White Mud River, both tributaries of Milk River, and Swift Current Creek, which flows north-east to the Saskatchewan. The White Mud River and Swift Current Creek, both head near the south-east corner of the hills, where they spread out into a plexus of coulées, often inosculating one with another, and are carrying on the work of demolition with great rapidity. The streams flowing north from the hills are insignificant in size, and with the exception of Ross Coulée, which flows into the Saskatchewan at Medicine Hat, empty into lakes which are all more or less saline, and have no present outlets. Drainage.

The height of the Cypress Hills plateau, which at its western end is nearly five thousand feet above the sea, gives it so cold a climate as to render it almost valueless for anything except stock-raising. But for this purpose, it seems especially adapted, as it possesses all the necessary requisites in a high degree. The snow-fall is light, and grass, water and shelter are everywhere abundant. Adapted to stock-raising.

I quote the following in regard to the flora of the Cypress plateau from Professor Macoun.*

"The flora of the Cypress Hills is very remarkable, and differs in many respects from that of the plains. In the coulées which extend into the hills on the north and east sides, the vegetation is almost exclusively eastern, and contains numerous forest species, while that of the plateau above, and the upper slopes of the hills have the prairie features Flora. Rocky mountain features of flora.

* Manitoba and the Great North-west, p. 192.

of the Rocky mountain flora, and both alpine and boreal species here find a home.

"In the upper part of the coulées amongst the spruce at the eastern end were *Spiræa betulifolia, Geranium Richardsonii, Habenaria rotundifolia, Phleum alpinum, Arenaria congesta* et *verna, Delphinium Menziesii*, and on the exposed gravel points and ridges that rose almost perpendicularly, were *Astragalus pauciflorus, Sedum stenopetalum, Cetraria nivalis, aculeata* et *Islandica, Polygonum imbricatum*, and *Vesicaria montana*. In the deep coulées, around springs of purest water, were large patches of *Mimulus luteus*, covered with a profusion of yellow flowers, and amongst the common sedges were *Carex festiva* and *capillaris*. These, all mountain species, and numerous others known to dwell there, told a tale that the botanist alone could understand. Whether the Cypress Hills were an outlier of the Rocky Mountains or not, their flora indicated that their climate was that of the foot-hills above Morley, and necessarily unfit to regularly mature cereals, although in sheltered valleys, barley and potatoes could possibly be raised.

Cold climate indicated by flora.

"The grasses of the plateau were of the real pasturage species and produced abundance of leaves, and were so tall that for miles at a time we had great difficulty in forcing our way through them. The chief were species of *Festuca, Danthonia, Poa, Avena pratensis, Bromus* and *Phleum alpinum*, and although their seeds were all ripe (August 14th,) their leaves were quite green.

"As we proceeded westward over the plateau, it became more elevated and other species began to take prominence, notably *Lupinus argentea*, and *Potentilla fruticosa* covered miles of country, to the exclusion of other species, and as both grew about eighteen inches in height, and had a bushy habit, the whole country, for a day's travel, was either blue or yellow or both, as either species prevailed or were intermixed. In all my wanderings I never saw any spot equal in beauty to the central plateau of the Cypress Hills.

Nutritious character of grasses.

"The grasses and other forage plants of the hills were those peculiar to coolness and altitude, but were all highly nutritious, and almost identical with those found on the higher plateaus at Morley. In all the valleys, and on the rich soil of the higher grounds, the grass was tall enough for hay. No better summer pasture is to be found in all the wide North-west than exists on these hills, as the grass is always green, water of the best quality always abundant, and shelter from the autumnal and winter storms always at hand."

Chinook winds.

"The pasturage of this region is identical with that on Bow River, and the climate seems just as dry, and I was informed that it felt the influence of the winter chinooks to some extent likewise."*

* Ibid, p. 252.

There seems to be no reason to doubt that the chinooks are felt as far east as the Cypress Hills, as the testimony of all the settlers to whom I spoke on the subject, was unanimous in regard to their occurrence at least two or three times every winter.

The supply of timber on the hills is considerable, more especially near their western end, where there is quite a large area covered with coniferous trees, and in other parts the coulées are all more or less wooded. There is also an abundant supply of fuel, of a different kind, as the lignite seam, which occurs near the base of the Laramie, is exposed in nearly all the large coulées. This seam varies in thickness from a maximum of five feet, and affords lignite of a very fair quality. Fuel supply.

Plains South of the Cypress Hills.

The range of plateaus which extends in an irregular manner from Sage Creek to Bull's Head, is bordered on the west by comparatively level plains, reaching to the western edge of the map and beyond. These plains are underlaid by rocks belonging to the Belly River series, and have an average height of about 3,000 feet. They are usually very barren, except towards Milk River, where the soil becomes better and supports a tolerable growth of short grass. From the edge of the plateaus east to Willow Creek the surface is broken by creeks and coulées flowing in a westerly direction. Willow Creek occupies an old valley which connects the drainage systems of the Missouri and the Saskatchewan, and separates the Bud Buttes from the Cypress Hills. Near the "Head of the mountain" this valley is well up on the slope of the hills, and going west from it, the country, in a few miles, descends below the level of its bottom. East of Willow Creek, along the base of the hills, the surface becomes very irregular, and is furrowed in all directions by a multitude of branching coulées flowing from the hills. Most of these coulées become united with Willow Creek before reaching the boundary line. Near the boundary a level or lightly undulating plain extends from Milk River to Boundary plateau. The soil underlying this plain is usually a stiff clay or hard loam derived from the underlying boulder-clay, and is, as a rule, hopelessly barren. Its sun-burnt surface, studded with small boulders, and split in all directions by shrinkage cracks, is scantily clad with a scattered growth of *Artemisia* and *Cactus*, separated by a few scattered blades of *Stipa spartea*. On some of the higher grounds the vegetation becomes somewhat improved, and the *Stipa* is associated with buffalo grass (*Bouteloua oligostachya*.) The plain is drained by two branches of Milk River, which, with their tributaries, wind through wide shallow valleys, enclosing desolate sage-covered bottoms, which are forbidding Plain west of Boundary plateau. Vegetation. Drainage.

in the extreme. Both of these streams are intermittent, and during the dry season hold water in pools only. North of this plain and south of Cypress Lake a sandy area of considerable extent occurs which is much better grassed.

Eastern boundary.

These plains are bounded on the east by a wide ridge, which, with one or two short breaks, extends from the Cypress Hills to the boundary. The northern part of this ridge is connected with the Cypress Hills, and is covered with high rolling hills, built principally of drift, which have a very côteau-like appearance. They extend south, but with somewhat diminished altitudes, to the edge of Old-man-on-his-back plateau.

Old-man-on-his-back plateau.

Old-man-on-his-back plateau and Boundary plateau, like most of the uplands in this region, are both well grassed, and in this respect, present a pleasing contrast to the sterile plains which stretch west from their base. They are of inconsiderable area, and towards the east, soon descend to the level of the plain which lies between the White Mud River and the boundary line.

Area of plain.

This plain contains an area of about 1,300 square miles, and has an average height of about 3,000 feet. It is usually more or less undulating, and occasionally swells into comparatively high ridges. Its soil is a hard bouldery clay-loam, or pure clay, and is usually rather barren, though in some places it supports a fair vegetation.

Plains East of the Cypress Hills.

Valley east of Cypress Hills.

The Cypress Hills are bordered along their eastern margin by a wide grass-grown valley, which is now followed in different parts by three separate streams, none of which, however, seem to have been its original occupant. Like the valley of Willow Creek, it forms a connecting link between the northern and southern drainage systems. Its eastern bank is much lower than its western one, and opens on a wide shallow depression, which extends to the western edge of Swift Current Creek plateau. This flat is mostly based on Fox Hill sandstone, and is very thinly covered with deposits of glacial age. It supports a fair vegetation. The plain north of it on both sides of Swift Current Creek, is dotted at intervals with small steep-sided conical hills built apparently of drift, either standing alone or united in short ranges, which are usually more or less curved in shape, and sometimes form complete circles. These hills look like miniature mountains and mountain-ranges, and are entirely different from any that I have seen elsewhere on the plains. They vary in height from thirty up to seventy-five feet.

Connects northern and southern drainage systems.

Remarkable hills and ridges.

Going in an easterly direction, the two low spreading plateaus of Swift Current Creek and White Mud River are next met with. Both

of these possess well-grassed, and more or less undulating surfaces. They are separated by the Middle Branch of Old Wives' Creek, towards which they present a somewhat abrupt face, but in other directions their slopes are generally very easy. The latter plateau is connected with Wood Mountain by a ridge which skirts the northern bank of White Mud River. The eastern part of Swift Current Creek plateau is divided up into a number of spurs, separated by branches of Old Wives' Creek, on some of which there are small groves of poplar. North of the eastern end of this plateau is a region of very high rolling hills, which extends nearly to Reed and Rush Lakes, where it is replaced by a more level country. Around these two lakes there is a considerable tract of very fair land.

Character of Swift Current Creek and White Mud River plateaus.

Going east from Swift Current Creek plateau, the country falls rapidly and spreads out into a wide plain, which extends east to the western edge of the Côteau. This plain is drained by the different branches of Old Wives' Creek, and contains an area of over 1,200 square miles, most of which is suitable for agricultural puposes. The soil is a sandy or clay loam of superior quality. The middle branch of Old Wives' Creek, which flows through the centre of the plain, contains a good deal of wood in places; chiefly ash-leaved maple. (*Negundo aceroides.*)

Wide plain.

Wood Mountain Plateau.

Wood Mountain plateau—the second largest in the district—is connected with the Laramie area of the Côteau and Souris River, of which it forms the westernmost part. It extends from the third principal meridian westward to the White Mud River, a distance of about forty miles, then bending more to the north it continues on to the middle branch of Old Wives' Creek, a further distance of about forty miles. The southern part of this north-western extension is sometimes called Pinto Horse Butte. Between Wood Mountain Post and the third principal meridian the plateau is about thirty miles wide, and has a heighth of about 3,200 feet. Its surface is very irregular, and is channelled in all directions by deep and wide coulées, the banks of which are usually grass-covered, and show only occasional exposures. These large coulées, many of which are now almost waterless, in common with similar ones in the Cypress Hills, imply a time when the rainfall must have been very much greater than at present. There is little or no denudation going on now, in this part of the plateau, and the present surface configuration must have been assumed long ago. West of Wood Mountain Post the plateau narrows in, and both its northern and southern slopes be-

Extent of Wood Mountain.

Surface.

Former period of greater rainfall.

come more abrupt. From this point on to its western end it seldom exceeds five or six miles in width, and is often much less. Its outline is sinuous and irregular, and consists of spurs thrust out between the various streams, alternating with deep bays. In some places it has been cut across by inosculating coulées. The surface of the plateau, where not broken up by coulées, is usually smooth or only slightly undulating, but near its western end it becomes very rolling and hilly, so much so as in some places to bear a strong resemblance to the Côteau country.

Suitable for grazing. Wood Mountain plateau and the country in its vicinity, like the Cypress Hills, is everywhere well grassed and well watered, and will, at no distant day, be extensively used as a grazing country. The wood supply is small, and is confined to the large coulées and to the edge of the plateau; but on the other hand, good lignite in large quantities can be obtained within easy reach of any part of the plateau.

The Côteau.

The Côteau enters the district covered by this report, north-east of Old Wives Lake, and crosses it in a north-westerly direction.

In this part of its course, while it preserves most of the distinctive features which characterize it elsewhere, it becomes very broad and diffuse, especially towards the Saskatchewan, and its western boundary is very difficult to define. **Eastern edge well marked.** Its eastern edge is well marked by an escarpment, which is 500 feet high where crossed by the trail between Moosejaw and Wood Mountain, but, going northward, this heighth decreases to about 300 feet at Secretan, and near the river to about 200 feet. **Height.** North of the river it increases again to over 300 feet. The line of this escarpment is indented by a number of deep bays, and its slope, though usually easy, becomes in some places very abrupt.

Western edge. The western edge of the hilly country crosses Old Wives' Lake, a few miles from its southern end, and then runs westward, south of Rush and Reed lakes to Swift Current Creek, which it crosses near Lonmay. From Lonmay it continues on to the Saskatchewan, which it reaches about ten miles east of Antelope Creek. **Extent of hilly country.** The country included between the line thus drawn, the Saskatchewan and the eastern edge of the Côteau, is, with the exception of the plains around Rush and Reed Lakes, generally very hilly, is boulder-strewn and dotted with small lakes. The hills are best developed in the south-eastern part of the area. **Flat plain north of Saskatchewan.** North towards the Saskatchewan, and west toward Swift Current Creek, they become much flatter. North of the Saskatchewan, a wide, flat plain intervenes between the Côteau and the valley of the river, at the edge of which the hills commence very abruptly, and continue on

beyond the limits of the map. In this part of the ridge, the hills are very steep-sided, and the confused medly of interlacing mounds and ridges which everywhere distinguishes the Côteau country, is particularly well shown. The height of the Côteau east of the south end of Old Wives' Lake, is 2,370 feet, at Secretan it is 2,259, and at the Vermilion Hills, south of the Saskatchewan, it has decreased to 2,230 feet. North of the river it becomes a little higher. Steep hills. Height.

PLAINS NORTH OF THE CYPRESS HILLS.

At the base of the steep escarpment which ends the Cypress Hills on the north, is a broken plain, which falls rapidly towards the north for the first few miles, after which it becomes more level, and stretches away to the Saskatchewan. This great plain, which embraces an area of nearly 8,000 square miles, presents an unusually diversified surface. Ridges of high rolling hills, covered with erratics, and extensive areas of bare sand-hills, alternate with broad plains of remarkable fertility, considering the aridity of the climate, and with wide sage-covered clay-flats, and every part of it is more or less thickly dotted with lakes, some of which, as Many Island Lake, Crane Lake, and Big Stick Lake, are of large size. The lakes vary through every degree of salinity, from those covered with a thick crust of crystallized salts down to others in which the water is perfectly fresh, and the two extremes are not infrequently met with side by side. At one point, near the west end of Bitter Lake, one of the most saline lakes in the district, a spring of fresh water was found bubbling up on the beach, and the same thing was noticed at several other places. As a rule, however, saline lakes occur more frequently in the low-lying areas, and fresh water lakes on the higher grounds. Northern slope. Area. Very diversified surface. Lakes. Position of saline lakes.

Another noteworthy feature of this plain is the utter absence of any general drainage system. A multitude of small streams, some of which carry considerable volumes of water during the spring floods, descend into it from the northern slopes of the Cypress Hills, but they are all intercepted at no great distance from their source by lakes where their waters are evaporated, and with the exception of Ross Creek and its tributaries, none succeed in reaching the Saskatchewan. In the central and northern parts, the evaporation is everywhere equal to the precipitation, and no streams of any kind are produced. Absence of drainage.

Sand-hills, covering more or less extensive areas, are found in every part of this plain. The largest area is known as the Great Sand-hills, and extends with a width of from ten to fifteen miles, from Crane Lake north about forty miles. At its southern end it sends narrow spurs west to Many Island Lake, and east, with one or two breaks, almost to Evaporation. Sand-hills.

Swift Current Creek station. The whole extent of this sandy waste amounts to over 500 square miles. Smaller sandy patches were observed near the mouth of Miry Creek, and also ten miles east from Red Deer Forks, and about six miles south of Sandy Point on the Saskatchewan, and a few scattered hills were found six miles north of Medicine Hat. The other more important sandy tracts occurring within the limits of the district, are the Middle Sand-hills, lying between the Red Deer and Saskatchewan, near their confluence, and the sand-hills found east of the Elbow, on the Qu'Appelle valley.

Formation of Sand-hills.

The areas of drifting sand are due to the action of the prevalent north-westerly winds, on an originally sandy and hilly region. Whenever by any means the protecting covering of matted roots is broken or removed, the dry light sands below, coming under the influence of the eddying currents of air, are carried away and piled up in long oval or rounded banks, across which, clouds of sand are constantly driving, and the process is continued until the main substance of the hill is gone, and nothing but its mere skeleton remains. Occasionally, parts of the hill which have been hardened by infiltrating matter, or rendered more compact by penetrating roots, and are therefore better prepared to resist the erosive force of the wind, remain standing after the softer portions have disappeared. Such fragments frequently assume rectangular shapes, and are usually covered with a shrubby vegetation. The floor from which a hill has been removed, is usually covered with pebbles and rolled bits of bone and lignite which have been sifted out.

Movement of Sand-hills.

All the different areas of sand-hills appear to be progressing slowly towards the east or south-east; the direction of the prevalent winds of the plains. The movement is plainly shown on the eastern side, by the hills being now underlaid by a loamy or clay floor, and on the western side by the solitary sand-hills, which are occasionally met with far in the rear of the advancing mass.

Vegetation.

The sand hills are not entirely destitute of all vegetation, but are occasionally partly covered with grass and shrubs of various kinds. The shrubs most frequently observed, were the choke-cherry (*Prunus Virginianus*) and the wild rose (*Rosa Sayi*). At one point a few miles east of Big Stick Lake, a number of large cotton-wood trees were seen.

Valuable plain.

Between the Great Sand-hills, and the Saskatchewan, is situated a level or slightly undulating plain, which will become very valuable when reached by the settlements. Its soil near the hills is sandy, but towards the river becomes loamy, and in many places is overlaid by several inches of black mould. It is also dotted with a considerable number of small fresh-water lakes. This plain extends west to the mouth of the Red Deer, and includes at least a thousand square miles of excellent agricultural lands. At present it does not contain a single

Extent.

settler. It is terminated on the east by an escarpment, facing the river and running parallel with it, which has the appearance of having been at one time the shore of a lake, or a former dilatation of the river. The soil on the plain stretching east from the base of the escarpment, consists of the disintegrated upper part of the boulder-clay. It is not very fertile, and supports a scattered growth of long thin grass. The surface of the plain lying west of the Great Sand-hills, is, as a rule, very undulating and irregular, and is intersected in a number of places by old water-courses and high bouldery ridges. It is everywhere fairly well grassed, and the parts which are too high and rough for cultivation will be valuable for pastoral purposes. South of the sand-hills, good agricultural lands are found around the west end of Crane Lake, at Maple Creek, Medicine Hat, and a number of other places along the line of the Canadian Pacific railway. That much of this land, notwithstanding its dry appearance, retains sufficient moisture throughout the season to enable it to produce excellent crops, has been amply proven by the operations of the last couple of years.

Plain west of Sand-hills.

Good agricultural land. Fine grazing country.

South of the railway line, the plain lying along the base of the northern slopes of the Cypress Hills, and extending west to the Bull's Head, is unsurpassed for grazing purposes by any part of the North-west. It is everywhere thickly covered with a heavy growth of nutritious grasses, which, according to Professor Macoun, are almost identical with those occurring in the Bow River country. Good water is found either in lakes or streams in every part of the plain, and ample shelter is afforded by the banks of the net-work of coulées which traverse it in all directions. Small wooded patches occur at intervals along the edge of the hills and in the valleys of the principal streams, and a seam of lignite, affording fair fuel, is also found in a number of places. This region, which seems fully equal to the Bow and Belly Rivers district as a stock country, has been ignored in the rush to the latter place, but is now beginning to attract attention.

Fuel.

Principal Rivers and Streams.

The only large river in the district is the south branch of the Saskatchewan, which runs across its northern part. The part of this stream above Medicine Hat has been described in the report for 1882-84. Medicine Hat is situated on a large clay-flat west of the confluence of the united waters of Seven Persons Coulée, Big Plume Creek, and Ross Creek, with the Saskatchewan. At this point, the river changes its previous direction somewhat abruptly, and runs about N. 30° E. as far as the mouth of the Red Deer. In this distance of about one

Medicine Hat.

Fall of stream. hundred miles, the river has a fall of about two feet per mile, and the current in low water runs at the average rate of about two and three-quarter miles an hour.

Tortuous course of stream. For twelve or fifteen miles below Medicine Hat the river follows a rather tortuous course, and makes a number of bends, all of which enclose large clay-flats, usually containing groves of cotton-wood. In the next section, extending as far as Drowning Man's ford, it is much straiter and the bordering flats become very narrow. East of Drowning Man's ford the river enters higher ground, and makes a sudden bend of several miles to the east and south, around which it runs with greatly increased speed, and at the same time, its valley, which hitherto has been somewhat tame, assumes a much more striking aspect. The

Canyon character of valley. sloping grassy banks which characterize it farther up, are replaced by high precipitous cliffs of bare grey rock, while it narrows in until in many places its breadth of bottom scarcely exceeds the width of the stream. The height of the plateau, above the river, in this part of its course is about 500 feet. The cañon-like character of the valley is maintained for over thirty miles, after which the Cretaceous rocks, by which it has been confined, gradually sink beneath the softer Post-tertiary

Depth of valley. deposits, and allow the river greater liberty of action. Between the eastern end of the cañon and the mouth of the Red Deer the valley is about a mile and a-half wide, and about 400 feet deep. Its banks, except near the bends of the river, are usually tolerably well grassed, and it contains at intervals a number of wide bottoms, some of which support large groves, principally of cotton-wood. A few miles above the mouth

Sand bars. of the Red Deer the channel of the river becomes obstructed with sand bars, and sandy islands are of frequent occurrence.

Disappearance of older rocks. The great drift-filled depression in the older rocks, in consequence of which they pass below the surface of the river, a few miles west of the mouth of the Red Deer, extends eastward for over seventy miles, and exerts an important influence on both river and valley. The width of both is at once greatly increased, and the channel of the former becomes filled with shifting sand-bars, a feature which characterizes it to a greater or less extent nearly all the way down to the Elbow.

Character of valley. The valley of the Saskatchewan east of the mouth of the Red Deer, is for many miles of a very uniform character, and will need only a few words of description. It is usually rather wide, and holds a number of large and valuable bottoms, which, especially in the upper part of this section, are often well wooded. The banks slope easily up to the prairie level, and are grass-covered nearly all the way, scarped banks being of very rare occurrence. At the mouth of the Red Deer the valley is about 400 feet deep, but going eastward this decreases to about 200 feet.

About thirty miles above the mouth of Swift Current Creek the valley narrows in and becomes very shallow, the banks scarcely exceeding fifty feet in height, although from their top there is a further gentle slope of about 150 feet up to the general prairie level, and at the same point the rocks of the Belly River series, which have been so long buried beneath the drift, begin to appear again in the bottom of the valley. Ten miles further on the river enters much higher ground, and the valley suddenly increases in depth to about 500 feet. From this point on to the eastern edge of the Côteau, a distance of about fifty miles, the appearance of the valley is exceedingly desolate and forbidding. The dark Pierre shales, which here form its banks, are peculiarly liable to land-slips, and all through this section the sides of the valley are covered with piles of *débris* which have fallen down from above, while the surface is still further confused by the numerous deep branching coulées which score it in all directions. All except the more recent of the land-slips have been worn by the action of the atmosphere into smooth conical hills, the dark bare surfaces of which are often covered with crystals of selenite. A few of the hills are also partially grass-covered, and groves of aspen and cherry are of occasional occurrence. Opposite Swift Current Creek the valley is about 600 feet deep and over three miles wide, and it remains about this size until it leaves the Côteau. Its bottom, which is about a mile wide, is divided up by the swinging course of the river into a series of long narrow flats

Re-appearance of Belly River series.

Increased depth.

Land-slips.

The portion of the river between the Côteau and the Elbow was not examined by me, and I quote the following description of it from Captain Palliser's report.*

"The valley of the Saskatchewan is about 1¾ miles in breadth at some distance above the acute angle which it makes to the north, called the Elbow, but at that place the banks are steeper, and the valley much more narrow . . . The river, averaging 600 yards in width, is depressed at the Elbow, 228 feet below the surface of the plain; but at the base of the Côteau the valley is very much deeper and wider, and the river channel winds through its bottom, leaving great points of dense wood on the left bank, but on the right great deposits of blown sand."

Width of valley.

The total distance between the mouth of the Red Deer and the Elbow —measured in three mile stretches—is about 180 miles. The elevation of the former point is 1,934 feet, and of the latter 1,595, which gives the river a slope of 1·9 feet per mile. The fall seems pretty evenly distributed, and there are very few rapids, but the large number of shifting sand-bars, which block the channel nearly all the way down,

Slope of river.

* Exploration of British North America, page 51.

Navigation difficult.

will make the navigation of this part of the river, except in high water, a matter of great difficulty. In some places, the river is nearly a mile wide, and splits up into half a dozen different streams, separated by wide bars or sandy islands, through which it is difficult for even a small boat to find a passage.

Swift Current Creek.

Swift Current Creek is a small rapid stream about forty feet wide, and from one to two feet deep, and has a total length of about one hundred miles. It rises in the eastern part of the Cypress Hills, from which it obtains most of its waters, and flows in a north-easterly direction for about seventy-five miles, then bending to the north, it empties into the Saskatchewan about sixty miles above the Elbow. In its upper part its valley is about a mile wide, and from two to three hundred feet deep, but nearing the Saskatchewan it has cut a rugged gorge, fully five hundred feet deep into the soft Cretaceons rocks through which it flows. With the exception of a few small groves of poplar, the valley of this stream is almost treeless until within a few miles of the Saskatchewan.

Deep gorge.

Old Wives' Creek.

Old Wives' Creek occupies a neutral position midway between the basins of the Saskatchewan and the Missouri. It empties into Old Wives' Lake,—a large lake without any present outlet. This stream has three main branches. The northern and middle ones rise in the Swift Current Creek plateau, the southern in the Wood Mountain plateau. The three branches, after uniting, form a stream twenty feet wide, and about a foot deep, and this represents the drainage of a region nearly five thousand square miles in area. The numerous secondary branches of this stream have cut deep gashes in the plateau where they take their rise, but after they become united farther out on the plains, their valleys are usually very wide and shallow. The valley of the middle branch is wooded at several points on its lower part. After uniting with the south branch it is covered for several miles with a thick forest, principally composed of the ash-leaved maple (*Negundo aceroides*). Old Wives' Creek, or its southern branch at least, may at one time have flowed eastward through the large and at present almost unused valley, connecting it with Twelve-mile Lake, and then through Big Muddy Creek to the Missouri, although to do so would necessitate a considerable change in the present relative elevation of the country.

Valley wooded.

Former course of stream.

Stream leaves old valley.

The middle branch exhibits at one point a good example of a stream diverted for some distance from its pre-glacial channel. As is usual in such cases, while the abandoned valley is wide and shallow, and evidently partially filled with drift deposits, the more recent one is narrow and gorge-like, and affords good sections of the rocks of the country. The change in the course of the stream has been effected either by obstructions in its channel, during the glacial age, or by a gradual elevation of the country to the south.

The White Mud River drains all the southern part of the Cypress Hills east of the Gap. It is the outlet of Cypress Lake, from which it flows eastward, cutting off in its course a portion of the Cypress Hills from the main plateau, and then bending more to the south, it continues on through the White Mud River plateau, to the eastern end of Wood Mountain, from which point it turns still more south, and crosses the boundary about twelve miles east of the 107th meridian, after a course on Canadian territory of about one hundred and thirty miles. Where it crosses the boundary it is about fifty feet wide. A peculiar feature of this stream is the way it has disregarded the low lands to the south and north in selecting a channel, and has chosen one through the higher plateau country, through which it has carved a valley, often upwards of five hundred feet deep, and from three to four miles wide. The valley is comparable in size with that of the Saskatchewan where it breaks through the Côteau, and is even more desolate in appearance, owing to the absence of all arborial vegetation. Its scarped banks are rugged and broken, and seamed with innumerable coulées, which afford a complete and almost continuous section of the various strata into which they cut. White Mud River. Strange course of stream. Character of valley.

Among the less important streams and valleys of the district may be noticed Battle Creek, Four-mile, and Medicine Lodge Coulées, all of which flow from the Cypress Hills southward to Milk River, and Big Plume Creek, and Ross Creek, which drain northward to the Saskatchewan. In Wood Mountain the Missouri system is represented by Little Rocky Creek and Poplar River.

Lakes.

The lakes are not confined to any particular locality or formation in the district, but are scattered more or less thickly over every part of it. They may be roughly divided into three classes—

(1) Lakes occupying portions of the abandoned channels of ancient streams. Classification of lakes.

(2) Lakes occupying depressions in the drift which have become the receptacle for the drainage of the adjoining higher land.

(3) Lakes partaking of the character of springs.

The lakes of the first class are few in number, but are usually rather large. Twelve-mile Lake will serve as a good example. This lake is about fourteen miles long, but its width seldom exceeds a mile, and it is closely hemmed in nearly all round by high scarped banks. It occupies part of a large valley which is continuous from Old Wives' Lake to the Missouri. A stream which enters this valley about a mile east of the lake, instead of flowing into the lake turns eastward, and Twelve-mile lake. Valley continuous to the Missouri.

eventually under the name of Big Muddy Creek, flows into the Missouri. The water-shed between the lake and this stream, in the valley, is 285 feet above Old Wives' Lake, and 211 feet above the mouth of the Big Muddy, thus if this valley ever carried water between Old Wives' Lakes and the Missouri, its present watershed must have since been elevated about 350 feet. The outlet and principal inlet of Twelve-mile Lake are both situated near its western end, and serve to keep that part of the lake comparatively fresh, but going east its water gradually becomes more saline, and near the eastern end the shore in some places is covered with salts which have crystallized out.

Elevation of water-shed.

Cypress Lake.

Another example of lakes of this class is afforded by Cypress Lake, which occupies a great valley connecting the East Fork of Milk River with the White Mud River. Cypress Lake is about ten miles long, and has a maximum width of about three miles. It is fed by streams issuing from the Cypress Hills, and its water is always clear and fresh. Near the eastern end of the expanded part of the lake there is a small island with high rocky banks, which has the reputation among the Indians of being haunted.

The lakes of the two latter classes, are, in many cases, so similar in appearance that it often becomes impossible to separate them, and very frequently a lake owes its existence to the combination of both causes. The majority of the lakes in the Côteau and in other similar areas of high rolling country, seem to belong to the third class. A few lakes in the second class are fed by streams, amongst which is Old Wives' Lake, the largest lake in the district. This lake is divided into two parts, each of which is about twenty miles long. The two divisions are united by a sluggish stream, about ten miles in length, into which Old Wives' Creek empties. The greater part of the lake lies in the Côteau belt, in which it occupies a depression about one hundred feet deep. The water of Old Wives' Lake is somewhat saline, but not so much so as to be unfit for use. Amongst the other lakes of the second class I may mention Many Island Lake, Big Stick Lake, and Crane Lake, three shallow saline lakes, each covering about thirty square miles, and fed by intermittent streams from the Cypress Hills. The lakes of the third class are usually very small; they occur in great profusion in the Côteau and other similar high rolling ridges, and are seldom long absent from any part of the district.

Old Wives' Lake

Lakes of the third class.

ELEVATION ABOVE SEA-LEVEL OF THE PRINCIPAL LAKES.

Old Wives' Lake	2,165 feet
Many Island Lake	2,280 "
Big Stick Lake	2,254 "

Crane Lake	2 420	feet.
Cypress Lake	3,240	"
Twelve-mile Lake	2,455	"
Devil's Lake	1,887	"
Wild Horse Lake	2,828	"
Elk Water Lake	4,020	"
Antelope Lake	2,304	"
Rush Lake	2,269	"
Hay Lake (Cypress Hills)	3,730	"

DESCRIPTIVE GEOLOGY.

THE CYPRESS HILLS AND VICINITY.

The Cypress Hills plateau is simply an outlier of the Wood Mountain, Côteau, and Souris River Laramie* area, which has escaped destruction on account of the thick deposits of Miocene conglomerates which everywhere cover it. The rocks observed in it are referable to the following series:— Cypress Hills plateau.

Miocene.
Laramie.
Fox Hill.
Pierre.

The Pierre shales, the Fox Hill sandstones, and the Laramie, here as elsewhere, are strictly conformable, and have a general north-easterly dip of about ten feet to the mile. The Miocene is laid unconformably on the Laramie, on which it usually rests, but in some places it overlaps and comes in contact with the Fox Hill. Strata conformable. Dip.

The west end of the Cypress Hills, forms a geological centre around which the formations mentioned above sweep in roughly concentric zones. I will define the boundaries of these formations in a general manner only, as they are all extremely irregular, and can be best learnt from the map which accompanies this report. The outer boundary of the Pierre shales, which forms the basal member of the Cypress Hills system, extends in a somewhat sinuous line from the Bull's Head plateau to the head-waters of Sage Creek, and then continues on to, and crosses the 49th parallel, a few miles west of the Boundaries.

* Throughout this report the name Laramie is used to designate the important series of deposits which follow the Fox Hill or "Cretaceous No. 5," in ascending order. The beds in Wood Mountain, also here referred to by this name, are an extension of those of the Souris River region which are the representatives of the typical Fort Union series of the Missouri. There is, however, every reason to believe that these and the farther western beds to which the name Laramie was first applied are equivalent in age.

fourth principal meridian. From the Bull's Head the same boundary also runs in a north-easterly direction to Irvine station, and then on to the South Saskatchewan, which it crosses about thirty miles west of Swift Current Creek. Between Irvine and the Saskatchewan, the rocks are entirely concealed by the drift, and the boundary is therefore somewhat uncertain. The boundary line just indicated, besides separating the Pierre from the Belly River series, also divides the district into two distinct parts, which differ from one another very materially in many respects, but more especially in regard to the distribution of the plateaus, all of which occur in the eastern part. The inner boundary of the Pierre shales is three or four miles distant from the base of the plateau near its western end, but in going eastward it gradually approaches and at length becomes coterminous with it. Still further eastward, owing to the decreased height of the country and in spite of the light easterly dip of the beds, the Pierre shales rise in the escarpments till they at length form nearly the entire substance of the plateau.

Pierre shales. The Pierre shales are well exposed all around the Cypress Hills, which they underlie throughout, and the dark clay banks which denote their presence can be seen in nearly every coulée leading from the plateau. **Sections on Willow Creek.** In the valley of Willow Creek, a few miles south of the "Head of the mountain," they are particularly well shown. At this point the valley is a couple of miles wide, and its long gently-sloping banks, which are formed entirely of Pierre, are scarped from top to bottom, and are worn into a succession of rounded hills, which are slowly wasting away. The surfaces of these hills are covered in some places with fragments of calcarious nodules, which have crumbled to pieces and which often contain *Ammonites* and *Baculites*, and occasionally a few vertebrate remains. The valleys of Battle Creek, Four-mile Coulée, and the White Mud River, are cut down through the Laramie and Fox Hill into the Pierre, and afford good exposures of the shales at many points. **Sections along northern slope.** Along the northern slope, the best sections are found south of Sidewood station, where several hundred feet of the shales is exposed in the banks of the numerous small streams which cut back into the plateau. Good sections are also found in the upper part of the valleys of Fish, MacKay, Big Plume, and Ross Creeks. In the valley of the latter creek the shales contain numerous nodules, which yield unusually good specimens of the ordinary Pierre fossils. A few miles west of the "Head of the mountain," at Bull's Head plateau, the lower part of the Pierre is well exposed, and is seen resting on the light colored beds of the Belly River series. The same thing was also observed on Big Plume Creek, Ross Creek, and further south, on the upper part of Sage Creek. **Large nodules.** The surface of the Bull's Head plateau section of the

shales is encumbered with gigantic calcareous nodules, some of which are from ten to fifteen feet in diameter. These nodules are usually roughly spherical in shape, and become yellowish on weathering. Some of them are fossiliferous, and the following species were obtained there:—*Callista Deweyanum*, *Protocardium subquadratum*, *Liopistha undata*, *Pteria lingueformis*, *Gervilia recta.*

Nodules somewhat similar to those at Bull's Head plateau were also found in an exposure of Pierre a couple of miles north-east of Irvine.

In the Cypress Hills region the Pierre shales are about 800 feet thick, and for the greater part consist as elsewhere of dark clay shales. The chocolate-colored sandy shales which form the upper part of the formation on the Red Deer and Belly Rivers, are replaced in this district by thick beds of greyish and yellowish sandstones. These sandstones, which are seldom persistent for any distance, are well shown on Battle Creek, and in the "Gap." The coal-bearing zone which occurs near the base of the shales farther west, is also found on Sage Creek, Ross Creek, and in all places where the base of the formation is exposed, though with greatly diminished importance. In the eastern part of the district the presence of this zone cannot be ascertained without boring, as the upper part of the formation only is exposed. **Thickness of Pierre.** **Coal-bearing zone.**

The Pierre is succeeded in ascending order by the Fox Hill sandstones. This formation is composed mainly of yellowish indurated sands and sandstones, and has a maximum thickness in the hills of about 150 feet. In some places the whole section is composed entirely of ferruginous sandstones, and the transition from the underlying argillaceous beds is very abrupt, but in most cases the lower part of the formation consists of alternating bands of sandstone and shale, and no distinct line can be drawn separating it from the Pierre, the upper part of which is always more or less arenaceous. The Fox Hill though never wholly absent, becomes in some places very thin, and as it is very closely connected with the Pierre, of which it simply forms an upper part, and is of no economic importance, no attempt has been made to represent it separately on the map. **Fox Hill sandstones.** **Composition.**

The Fox Hill is well exposed in many places both north and south of the hills. Very characteristic exposures occur on a tributary of Willow Creek, a few miles south of the "Head of the mountain," where the following section was observed:— **Exposures of Fox Hill.**

	FEET.
1 Greyish sands	20
2 Dark clays	40
3 Greyish and yellowish sandstone	30
4 Dark clays	30
5 Dark rusty and light yellowish coarse soft sandstone	130
6 Dark shales (Pierre)	—
	250

Sand-hills. The upper part of this section is probably Laramie. The thick band of yellowish sandstone near the base of the section is very soft, and near the edge of the coulée, where it is unprotected, it has been disintegrated and blown into sand-hills. Good sections also occur on Battle Creek, in the "Gap," and at many points along the White Mud River. A few miles east of East End Coulée the Fox Hill appears from beneath the Laramie, and then forms the surface of the hills nearly all the way to Swift Current Creek. It is also found south of the hills in Old-man-on-his-back plateau, which is capped with about 150 feet of ferruginous sandstones. In the plains north of the Cypress Hills and west of the Côteau, the Fox Hill has entirely disappeared, and the greater part of the material of the sand-hills now existing there has no doubt been derived from it.

Laramie. The Fox Hill is overlaid conformably by the Laramie, a formation whose precise position in the geological scale has been a matter of much dispute, but which is now pretty generally regarded as a transitional one between the Cretaceous, properly so called, and the Tertiary.

Junction of Laramie and Fox Hill. The junction between the Laramie and the Fox Hill is marked by no sudden lithological break, and it is often difficult to determine the exact point at which one is replaced by the other. I have usually drawn the line of separation near the base of a thick band of greyish sandstone, which seems to mark nearly everywhere in this district, the base of the Laramie. This sandstone differs from the Fox Hill sandstone in colour, and also in the absence of clay-ironstone nodules containing *Ammonites* and *Baculites*, which is so persistent and typical a feature of the latter.

Thickness. The portion of the Laramie represented near the west end of the Cypress Hills has a thickness of about 800 feet, but this gradually decreases eastward, and also becomes very irregular, owing to the unequal effects of denudation at different places both before and since the deposition of the Miocene. In some places, as in the "Gap," and also at the East-end Coulée, it has been entirely swept away, and the lower formations uncovered.

Best exposures. The best exposures of the Laramie occur along the valley of the White Mud River, between Cypress Lake and East-end Coulée. This valley is in some places fully 600 feet deep, and its banks, which are always more or less scarped, afford very complete sections of all the formations found in the hills. The following somewhat detailed section was obtained a short distance above the trail-crossing of the White Mud River near East-end Coulée. It is in descending order, and commences about fifty feet from the top of the bank, the upper part of which is grass-covered.—

		FEET.
1.	Greyish and yellowish sands and clays, sands very fine grained, color predominantly yellow	50
2.	Greyish and yellowish clays	15
3.	Carbonaceous shales	5
4.	Soft yellowish indurated sands showing false bedding	30
5.	Dark carbonaceous shales	4
6.	Yellowish and greyish, soft, and somewhat arenaceous clays	6
7.	Yellowish clays, sands, and sandy clays	30
8.	Carbonaceous shales, containing a small seam of inferior lignite	6
9.	Yellowish arenaceous clays	20
10.	Carbonaceous shale	2
11.	Yellowish and greyish sandy clays or silt	10
12.	Light brownish and greyish clays	15
13.	Yellowish and greyish sandy clays containing some ironstone	10
14.	Carbonaceous shales and impure lignites	4
15.	Yellowish and greyish sands, clays, and sandy clays	30
16.	Carbonaceous shales containing a small seam of inferior lignite	6
17.	Dark clays	30
18.	Greyish clays	4
19.	Very light grey, slightly undulated sands	20
20.	Carbonaceous shales	1
21.	Very light grey, slightly indurated sands	15
	Total Laramie	313
22.	Yellowish sands containing some beds of hard sandstone and a number of ironstone nodules Fox Hill	120
23.	Greyish and dark clays Pierre	78
	Total thickness of section	508

The upper part of this section has a general yellowish colour, viewed from a distance, but on closer inspection it is found to contain a number of small grey and dark beds, and is composed almost entirely of sands and pure and arenaceous clays. Small beds of carbonaceous shale occur throughout the section, and often contain thin lignite seams. There is a marked absence of hard sandstones in the exposures at this point, but on the other side of the valley a little farther up the stream, a thick bed of hard sulphur-yellow and mostly falsely bedded sandstone forms the upper part of the Laramie, and in other places similar nodular non-persistent beds occur occasionally in different parts of the section. Below this series of sands, clays and silts, and forming the lower part of the Laramie, there is nearly always found a band of

Appearance of sections.

Absence of hard sandstones.

White band.

clays and sands, which in many places has been bleached almost pure white by the action of the vegetable debris now represented by carbonaceous matter. This band, though only from twenty to fifty feet thick, forms, owing to its color, a very conspicuous feature of the section, and can be seen for miles up and down the valley. Exposures of it, in the distance, look like great snow-banks. The clays and sands in it, like those above, graduate almost imperceptibly one into the other, and seldom remain pure for any distance. They are usually associated with small beds of carbonaceous shale and lignite. This grey band has a very wide distribution, as it is found in the White Mud River plateau, in the Laramie area south of the east end of the Cypress Hills, in Wood Mountain, and also in the Côteau north of the South Saskatchewan. Very fine exposures of Laramie also occur a few miles farther up the valley of the White Mud River near the mouth of Fairwell Creek, where the following general section was measured:—

Distribution of white band.

	FEET.
1. Yellowish very fine-grained arenaceous clays, passing into pure clays and sands	110
2. Greyish clays, carbonaceous shales, and thin beds of lignite, yellowish sands, clays, and sandy clays	120
3. Greyish shales	6
4. Carbonaceous shales	4
5. *Lignite*	3
6. Greyish shales	30
7. Brown carbonaceous shales	6
8. Grey and almost pure white sands and clays	50
9. Coarse rusty yellow sands (Fox Hill)	125
10. Lead-grey and dark shales (Pierre)	50
	504

The two upper divisions of this section, though very similar lithologically, appear quite distinct when seen from a distance owing to the difference in colour, the lower one having a general greyish colour, while in the upper yellowish tints predominate. The general composition of the Laramie, as developed in the south-eastern part of the hills, may be briefly described as consisting of a lower light-grey band of sandstones and clays, underlying a carbonaceous zone, which usually includes a lignite bed from two to three feet thick, and is overlaid by a series of sands and pure and arenaceous clays. The coarser varieties of the sandstone in this series are usually affected by false bedding.

General compositions of Laramie.

Exposures.

The Laramie appears at intervals along the southern part of the eastern escarpment of the hills, and at one place was observed to include a thick bed of grey sandstone which weathers into monumental forms; but going farther north, it thins out rapidly, and near the

north-east corner disappears, and the Miocene and Fox Hill come into direct contact. The following section will explain the arrangement of the beds in this part of the hills:—

	FEET.
1. Pebble conglomerate	30
2. Coarse soft yellowish sandstone	60
3. Clays, looking dark in bank, but yellowish and greyish on fresh exposure	80
4. Yellowish sandstone containing ironstone nodules	50
	220

The northern escarpment of the Cypress Hills between East-end Coulée and the "Gap" is grass-covered, and affords no exposures of any importance. West of the "Gap," the Laramie is seen at several points in the northern slope of the hills, and also in the banks of the valleys of Four-mile Coulée and Battle Creek, but all the exposures are very inconsiderable. The best one occurs a couple of miles west of Elk-water Lake, at which point an extensive land-slide, or a series of slides, has uncovered the face of the escarpment. The section here, in descending order, consists of a bed of pebble conglomerate, about fifty feet thick, beneath which is a rather hard bed of sandstone, from three to four feet thick, which weathers to a dull reddish color, and shows false bedding. It is underlaid by softer greyish and yellowish sands, and these by bluish clays. The strata brought down by the slide include clay beds of different shades of red, yellow, and bluish-green. The rocks exhibited in this section are higher in the Laramie than any seen elsewhere in the hills.

Section near Elk-water Lake

In the upper part of the valley of Battle Creek the following section was obtained. It occurs near the base of the Laramie, and is given in descending order:—

	FEET.
1. Bluish clays	20
2. Yellow sands	50
3. Carbonaceous shales	2
4. Greenish and bluish clays	40
5. Yellowish and greyish sands	30
	142

This section, which is on nearly the same horizon as the white beds on the White Mud River, together with a few other smaller ones, found at different places west of Battle Creek, seem to show that the divisions of the Laramie, as exhibited in the south-eastern part of the hills, are not applicable here, and also that the beds of fine sandy clays or silts, which occupy such a large proportion of the section there, are replaced in this part by beds of pure clay and indurated sand.

Carbonaceous zone.

The carbonaceous horizon, which exists nearly everywhere near the base of the Laramie, is found all round the western end of the hills, and contains in several places a workable seam of lignite. This seam has been burnt in many places around the north-west corner of the hills, and can be traced from point to point by the zone of reddened rocks thus produced. It is found near the northern end of Elk-water Lake, where it occupies a position about half way down the bank, and has a thickness of about three feet, and it is also exposed in nearly all the larger coulées leaving the western end of the hills. The following section around it was obtained on a tributary of Willow Creek, a few miles south-east from the "Head of the mountain."

	FEET.	INCHES.
1. Dark clays	—	—
2. Yellowish sandstone	40	—
3. Carbonaceous shale	6	—
4. *Lignite*	2	6
5. Carbonaceous shale	5	—
6. *Lignite*	4	—
7. Carbonaceous shale	3	—
8. *Lignite*	1	6
9. Carbonaceous shale	2	—
10. Grey soft sandstone	4	—
11. Carbonaceous shale	2	3
12. Grey sandstone	2	3
13. Carbonaceous shale	4	—
14. Soft, grey, massive sandstone	15	—
	91	3

The same seam, or one occupying approximately the same horizon, was also observed in several places along the White Mud River, in the south-eastern part of the hills, but in none of these exposures it is over three feet thick, and its quality here is usually inferior.

Fossils

With the exception of fragments of silicified wood, which are very plentiful in a number of places, no fossils of any kind were found in the Laramie deposits of the Cypress Hills.

Miocene.

The Laramie seems to have been elevated, and to have suffered extensively from denudation before the deposition of the Miocene, which, as already stated, overlies it unconformably, and which forms the surface in all the higher parts of the Cypress Hills, and covers an area of upwards of 800 square miles. The Miocene has been removed from the lower part of the plateau included between Battle Creek and Four-mile Coulée, from the "Gap," and from the depression running across the hills north of the east end of Cypress Lake, and has also been cut through by all the larger coulées. West of the "Gap," this formation consists of a uniform sheet of hard conglomerate, about 50 feet thick, which is well exposed

in many places in the valleys of Battle Creek, Four-mile Coulée, and along the edges of the plateau. In the eastern part of the hills the conglomerate is usually associated with beds of sandstone, sands, clays and marls, and the thickness of the whole deposit increases to about 500 feet.

The conglomerate which forms such a marked feature of the Miocene deposits of the Cypress Hills, is usually composed of quartzite pebbles cemented together by carbonate of lime, but also appears under a number of other forms. In some places the pebbles lie loosely in a matrix of coarse yellowish sand, and in others they are consolidated by a ferruginous cement. Beds several feet thick also occasionally occur, which contain nothing but loose pebbles. The conglomerate sometimes contains interstratified beds of coarse sands, into which the pebbles seem to grade, and also beds of white, or cream-coloured clays and sands, which occasionally hold calcereous nodules, some of which when broken across were found to be spotted by small black concretionary grains of oxide of manganese. The pebbles of the conglomerate are nearly always composed of hard quartzite, and vary in size from coarse sand to eight and nine inches in diameter, though the usual size is from two to four inches. They are usually white on a fresh fracture, but grey and flesh-coloured tints are also common. They are sometimes found forming the lower surface of hard sandstone beds, or scattered more or less sparingly through them. Beds of pebble conglomerate, though more frequent and larger near the base of the Miocene, are found at irregular intervals all through it, and are of all thicknesses, from a single layer of pebbles up to beds fully fifty feet thick. In many cases the formation consists of a single thick bed of this rock. Besides the pebble conglomerate, beds composed of angular pieces of clays enclosed in a matrix of hard sandstone, and forming a species of breccia, are occasionally found. Conglomerate. Pebbles of conglomerate.

Ths sands of the Miocene sometimes form hard beds, from one to two feet thick, but are usually only slightly indurated, and are nearly always affected by false bedding. In one place, near the eastern escarpment, a bed was observed which consists of hard, clean, angular, silicious grains, nearly all of uniform size, and apparently quite loose and unstratified. This bed contained a few pebbles and rolled fragments of fossilized wood and bones. Sands.

Small beds of impure carbonate of lime, or marl, are also occasionally found amongst the deposits of this formation, and are worth mentioning, as they may become of some economic importance, on account of the scarcity of limestone on the plains. They are usually white or light-yellowish in colour, are seldom very hard, and are filled with small nodules, composed of varying proportions of sand and calcite. They Marl.

seem to underlie the surface over a great part of the hills, a fact shown by the material brought up by burrowing animals, when other exposures are wanting.

Sections of Miocene. Good sections of Miocene rocks occur in the eastern part of the hills in the banks of the valleys of Fairwell Creek, the White Mud River and along the eastern escarpment. In the valley of the White Mud, beds of pebble conglomerate, occasionally associated with some whitish marls or yellowish sands, the whole measuring fifty or sixty feet, crop out near the surface at intervals all the way between Cypress Lake and the mouth of Fairwell Coulée. East of Fairwell Coulée, the deposit becomes much thicker, and the conglomerate is overlaid by about a hundred feet of dark greyish clays and sands. A very good exposure, about 150 feet thick, is found in the eastern escarpment, a short distance south of East-end Post. At this point, the lowest bed consists of hard, greyish sandstones holding some pebbles, and also some angular fragments of hard, greyish clay. This bed is overlaid by coarse, brownish-red sands, and the sands by reddish, greyish, and dark clays, interstratified with some beds of loose pebbles. In the north-eastern end of the hills, the upper part of the formation has been swept away, and scarcely anything except a single thick bed of conglomerate remains.

Best exposures. The best exposures of Miocene are found in the banks of a large coulée, which crosses the hills a few miles west of the eastern escarpment. This coulée contains Fairwell Creek, which flows south into the White Mud River, and also a stream flowing north into Swift Current Creek. These two streams, near the central part of the plateau, split up into a great number of branches, which ramify in all directions, and cut deeply into the soft Miocene deposits, which here attain their greatest development. Numerous exposures occur on both the main coulée and its branches, but they are nearly always small and fragmentary, and nowhere could anything approaching a complete section be obtained. The rocks exhibited in these sections consist of pebble and clay conglomerates, with occasional beds of loose pebbles, hard and soft sandstones, the latter usually very coarse-grained and affected with false bedding, clays of various colors, but usually dark grey, and small beds of impure limestones and whitish marls. **Thickness.** The total thickness of the whole deposit at this place is about 500 feet, but going west, it thins out rapidly, and in a few miles everything but the pebble conglomerate disappears.

Mammalian remains. A number of interesting mammalian remains were found in these beds while examining them in 1883, and since then, Mr. T. C. Weston has made a much larger collection, and the whole has been placed in the hands of Professor Cope for examination. The only invertebrate fossils found were some casts of Unio shells.

T. C. Weston, Phot., June 13, 1884. Artotype—Canada Bank Note Co., Montreal.

HEAD WATERS OF SWIFT CURRENT CREEK, CYPRESS HILLS.

BANKS OF VALLEY SHOWING OUTCROP OF MIOCENE CONGLOMERATE.

Newer conglomerates. In a couple of places south of the "Gap," along the valley which connects Cypress Lake with the East Fork of Milk River, some small areas of conglomerate were found, which are probably of the same age as the incoherent gravels and conglomerates found in so many places, beneath the drift, in the valleys of the larger streams (compare Report of Progress, 1882-84. p. 140, c.).

SWIFT CURRENT CREEK PLATEAU.

Swift Current Creek plateau. Swift Current Creek plateau is a low diffuse ridge, situated north-east from that of the Cypress Hills and separated from it by a shallow depression about twelve miles wide. It is about forty-five miles long and twenty wide, and has an elevation of four to five hundred feet above the plains around it, or 2,930 feet above the sea. Its surface is usually undulating, but in some places becomes very hilly, and its edges show comparatively easy slopes, and nowhere present the abrupt escarpments so characteristic of Wood Mountain and the Cypress Hills. It is drained on the north by Swift Current Creek, which runs through the plateau for some miles, and on the south by the different branches of Old Wives Creek. A deep valley has been cut completely across it, by a branch of the former stream inosculating with one from the latter.

The easy slopes of this plateau, the grass-covered condition of most of its valleys, and the consequent absence of any extensive exposures, renders the collection of details in regard to its geological structure a task of some difficulty. Its main features, however, are simple and easily understood. Two formations only enter into its composition, viz: the upper part of the Pierre shales and a deposit similar in composition to the Miocene rocks of the Cypress Hills. The latter formation, which is referred to the Miocene, rests unconformably on the Pierre; the Fox Hill and Laramie being usually absent. This plateau suffered more severely from the effects of denudation previous to the deposition of the Miocene than the Cypress Hills, as not only have the Fox Hill and Laramie been almost entirely swept away, but part of the Pierre also has disappeared. Composition.

Pierre shales. The Pierre shales, in the north-eastern part of this plateau, present a somewhat strange appearance to one accustomed to their dark tints elsewhere, as here at a distance they look almost white. The lightness of the color, is, however, partly due to bleaching, as in a fresh exposure, light-grey and bluish tints prevail. The difference in color, is accompanied by a corresponding change in composition, as they have become more arenaceous, and in places pass into a soft sandstone. The foliation is also unusually coarse, and the different beds often exhibit slight differences in color due to their more or less arenaceous Change in color and composition.

character. The faces of some of the sections are studded with large arenaceous nodules, which are frequently incrusted with radiating crystals of selenite. Shales answering to the above description are exposed in a number of sections along Rush Lake Creek, and some of its branches, and are there usually overlaid by a heavy bed of conglomerate.

Shales darker. A few miles farther west, on Swift Current Creek, where the shales are next met with, they are darker in color, but are still very arenaceous, and it is possible that some of the upper beds may represent part of the Fox Hill.

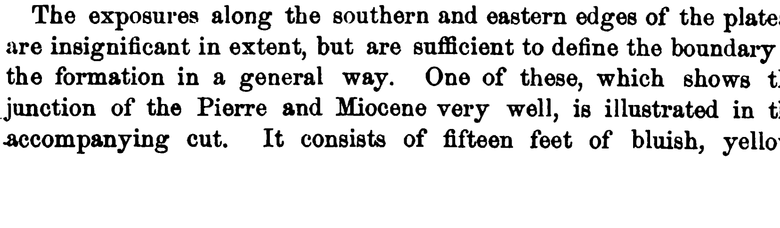
Exposures of shales. The Pierre shales, with the exception of a short interruption after the stream enters the plateau country, are exposed along the whole length of Swift Current Creek, from the Cypress Hills to the Saskatchewan, the fall of the stream being almost identical with the dip of the formation. They are also exposed in a number of places along the southern and eastern edges of the plateau, in the valleys of the different branches of Old Wives Creek. One of the exposures near the south-eastern edge of the plateau in Township 10, Range xi., west of the the 4th Principal Meridian, yielded a number of fossils, amongst which are:—*Yoldia Evansi*, *Lucina occidentalis*, *Neæra Moreauensis*, *Actæon attenuatus*, *Anisomyon centrale*, *Anchura Americana*, *Scaphites Nicolleti*, *Schaphites Subglobosus*.

Pierre overlaid by Miocene. The Pierre shales are usually overlaid unconformably by the Miocene. At one point near the north-eastern edge of the plateau an exposure of yellowish and greyish sands and silts, and greyish and dark clays was observed, which may possibly belong to the Laramie, and coarse yellowish sandstones, resembling the Fox Hill, were seen in a couple of places; but in most cases, these formations are absent, and the Miocene rests directly on the dark argillaceous clays of the Pierre.

Miocene. The Miocene deposits of Swift Current Creek plateau, while resembling in a general way, the corresponding rocks in the Cypress Hills, differ from them in containing a smaller proportion of pebble conglomerate, and in the superior hardness of some of the sandstone beds. Best exposures. The best exposures are found in the valley, noted previously as crossing the plateau transversely, the banks of which afford a broken section of about 300 feet. This section was too fragmentary to admit of any detailed measurements, but the rocks exhibited in it may be generally described as consisting of coarse false-bedded sandstone, with occasional beds of a harder finer-grained variety, usually greyish or light-yellowish in color, hard silicious sands, clays, shaly clays, marls and pebble conglomerates. Conglomerate. The conglomerate usually forms a compact rock, the pebble being held together by a hard, calcareous cement, but in some places its constituents are very feebly consolidated, and occasionally

they lie quite loose in the bed. The pebbles, which are always well-rounded, are formed of hard, light-coloured quartzites, and are probably like those of the Cypress Hills, derived from the Cambrian quartzites of the Rocky Mountains. In addition to the rocks mentioned above, beds of impure nodular limestone are of occasional occurrence. These beds, which are very characteristic of the Miocene, are only slightly indurated, and when subjected to the influence of the atmosphere, soon crumble away and cover the bank with small nodules, ranging in size up to about half an inch in diameter. The general section presents a somewhat greyish appearance at a distance, owing to the obtrusive whiteness of some of these calcareous beds, although most of them are found to be more or less yellowish on closer inspection. The conglomerates in this section, are not developed to nearly the same extent as in the corresponding sections in the Cypress Hills, a fact due, no doubt, to their greater distance from the mountains, but toward the outskirts of the deposit they become relatively much more important, and occasionally the whole formation is reduced to a single thick bed of this rock. Nodular limestone.

The Miocene sections on Swift Current Creek begin a few miles above the crossing of the Canadian Pacific railway with a single bed of conglomerate. Farther up, this bed becomes associated with irregular deposits of silts, sands and clays, which disappear again as the western boundary of the formation is approached. The sections on this stream are sufficiently well exposed to show that there is a small but well-defined dip towards the centre of the area, and that the Miocene occupies a shallow basin-shaped depression in the Pierre. This fact, taken in connection with the general irregular character of the deposits, the prevalence of false bedding, and the decreasing proportion of conglomerates towards the centre, show the formation to be of lacustrine origin, and it was probably deposited in a dilatation of some large river flowing eastward from the Rocky Mountains. Miocene on Swift Current Creek. Origin.



SECTION SHOWING MIOCENE BEDS SUPERPOSED ON PIERRE SHALES.

The exposures along the southern and eastern edges of the plateau are insignificant in extent, but are sufficient to define the boundary of the formation in a general way. One of these, which shows the junction of the Pierre and Miocene very well, is illustrated in the accompanying cut. It consists of fifteen feet of bluish, yellow- Exposures along southern and eastern edges.

weathering, fine-grained argillaceous sands holding calcareous nodules, resting on the Pierre and underlying about fifteen feet of pebble conglomerate. In this section, small beds of sand are enclosed in the conglomerate.

Bed of conglomerate.

On Rush Lake Creek, the Pierre is overlaid by a single thick bed of conglomerate, the extent and relations of which could not be very well worked out, owing to the infrequency of exposures, but which probably post-dates the Miocene in age.

Fossils.

The only fossils which I succeeded in finding in the Miocene of this plateau were a few indeterminable fragments of the remains of vertebrate animals. Invertebrate fossils seem to be entirely absent.

Drift.

There are a few Laurentian boulders scattered over Swift Current Creek plateau, but otherwise, except on its northern boundary, it is entirely driftless. This fact is of some importance in tracing out the Miocene, as its junction with the Pierre can be defined approximately by noticing the difference in the materials brought up by burrowing animals; the light-colored calcareous *débris* brought up by animals burrowing into the Miocene being different from that seen when the surface is underlaid by Pierre or boulder-clay.

Geology of the Country South of the Cypress Hills.

The rocks underlying the surface of the country in the south-western corner of the map are well exposed in the almost precipitous and scarped banks of the valley of Milk River, and also a little farther north in the valley of Many Berries Creek, the outlet of Lake Pā-kow-ki. These two streams occupy valleys from 200 to 300 feet in depth, and from a mile to a mile and a half in width, the banks of which afford magnificent sections of the rocks belonging to the Belly River series, into which formation they are cut.

Milk River valley was visited and examined by Dr. G. M. Dawson in 1874, while connected with H.M. North American Boundary Commission Survey, and the following detailed description is quoted from him :—*

Milk River valley.

"The valley of the Milk River is one of the most important features met with on the line of the forty-ninth parallel, and offers continuous and magnificent sections of beds referable to the Lignite Tertiary series. The country on both sides of it, is seamed with tributary ravines and gorges, the banks of which are often nearly perpendicular, and which ramify in all directions. Where the Line crosses the river

* Geology and Resources of the Forty-ninth Parallel, 1875, p. 117. The quotation is given at length, as the volume is now out of print. The beds described were at the time supposed to be of "Lignite Tertiary" (Laramie) age. See Report of Progress, 1882-84, pp. 45 C-122 C.

valley, it is utterly impassable for waggons or carts, and near this place the Great Dry Coulée branches off, which, according to Palliser's map, runs to Lake Pā-kow-ki. The appearance of the valley of the river itself is strange and desolate.

"The banks rise nearly 300 feet above the level of the stream, and are more than a mile apart. They are almost bare of vegetation, and marked by bands of different colored clays and sandstones in a nearly horizontal position, as far as the eye can reach. The descent into the valley cannot be made on horseback but by taking advantage of the well-worn buffalo tracks, which are found leading down almost every coulée and ravine. The river itself is comparatively insignificant, and winds in broad curves from side to side of the valley, and is fringed by a grove of large poplar trees, and by willows. The bottom of the valley is marked out into three distinct levels, differing much in appearance, though only by a few feet in height. Over the first of these the river must constantly pass in flood. It shows in many places a luxuriant growth of grass, and supports most of the timber. The second level, which the river can seldom if ever touch, is characterized by the abundant growth of *Artemisia* of several different species. A third level, which forms a kind of low terrace at the foot of the cliffs, and must be twenty to thirty feet above the stream, consists of hard, parched clay, the washings of the banks, and nourishes only the grease-wood, and a few other thick-leaved drought-loving plants. Appearance of valley.

"The sections on the banks are undisturbed and regular. The beds are divided into an upper and lower series, by a zone of sandstones, which is about two-thirds up the bank near the Line, but about eight miles north-westward up the valley, is found forming the very summit of the cliff; which here, from the better support afforded by such hard rocks as compared with the clays and arenaceous clays of the rest of the formation, assumes a bolder and more rugged aspect, and a greater height than elsewhere. Fourteen miles south-eastward of the crossing of the Line, the same sandstone zone is again seen, but now only about one-third up the bank, indicating a general inclination of the beds in a south-easterly direction—which may not be exactly that of the full dip—of about ten feet to a mile. Sections.

"The sandstones, though often well and evenly bedded, are not regularly hardened, but have a nodular character; and though in some localities indurated throughout their entire thickness, in other places not far removed, they may show only certain hard layers of comparatively small thickness, separated by beds of unconsolidated sand. They appear, however, to be very constant in extent, and do not differ materially in thickness at the several localities where they were examined. They are slightly ferruginous, with prevailing light yellow tints, and are often more or less affected by false bedding. Sandstones.

Rocks below sandstones.

"Below the sandstones occur clays, sands, and arenaceous clays generally well stratified, and individual beds of which may often be traced a long way up or down the valley. The colors are usually light, but there are some zones of darker carbonaceous clays, and in a few places impure lignites of no great thickness were observed. These appeared to be less persistent than most of the other beds, and generally to thin out and disappear when followed far in either direction.

Origin of lignites.

From their appearance, and mode of occurrence, these lignites may well have originated from the drifting together of wood or peaty matter, and differ considerably from the pure and definite beds which characterize the Lignite Tertiary further east, and which appear to be formed of trees which have grown on the spot.

"Above the sandstone zone is a great thickness of sands and arenaceous clays, forming more massive beds, in which the stratification is less perfectly marked. The general tints are pale greenish-grey, greyish, and light buff.

Fossils.

"No fossils were found in this upper series or in the sandstones. In the beds below the sandstones, organic remains are also singularly rare, but are not altogether absent. In a part of the section not far below the base of the sandstone zone, is a layer with great arenaceous concretions, which contain in some places abundance of fossils."

Amongst these are *Campeloma productum*, one or more species of *Vivipara*, two species of *Corbula*, a *Helix*, and *Sphærium formosum*, var.*

"A few rolled fragments of bones are also included in the bed, and some traces of fossil plants. Lower down in the section valves of *Ostrea* are found, sparingly scattered through the deposit, and not very far from the base, a layer containing shells of *Unio* in a poor state of preservation was observed. Near the latter were found fragments of

remains.

the bones of a large vertebrate. They were scattered, and not in a very good state of preservation, and had evidently been strewn about after the death of the animal, and before their envelopment by the sediment. These, with the other vertebrate remains, were submitted to Prof. Cope, who pronounced them to be portions of the sacrum and long-bones of a Dinosaurian.

"A section of the upper beds and sandstones, observed in a ravine on the east side of the Great Dry Coulée, near the Line, showed the following succession of beds:—

* The names of fossil molluscs here given have been revised by Mr. Whiteaves in conformity with his later researches.

	FEET.	INCHES.
1. Light yellowish arenaceous clays and sands, indicated in slopes and higher grounds, but of which a few feet at the base only are well exposed	6	8
2. Grey sand	4	5
3. Grey-green arenaceous clay	9	0
4. Arenaceous clay (rusty, irregular layer)	2	3
5. Highly ferruginous layer. A few inches.		
6. Grey arenaceous clay, rather conspicuously banded	17	10
7. Grey soft sandstone	14	5
8. Sandstones, hard and soft, brownish, yellowish and grey; often concretionary, generally well stratified, but sometimes false-bedded, forming cliffs in the gorge, and weathering out into overhanging ledges, and horizontally fluted walls	35	6
About	90	0

"The most complete section of the beds below the sandstone zone was obtained about eight miles north-westward from the intersection of the valley with the Line, and on the north-east side of the valley. It may overlap the last by a few feet, or a few feet may be omitted; but, allowing for this slight uncertainty, it forms a continuation downward of the base of the former section. Most complete section.

	FEET.	INCHES.
1. Soft grey sandstone, forming the top of the bank (about)	4	6
2. Red-brown concretionary sandstone, with large flattened nodules	4	6
3. Hard grey sand	4	5
4. Reddish nodular sandstone	2	0
5. Whitish arenaceous clays, with some selenite in the lower layers	22	6
6. Greyish and yellowish arenaceous clays (banded)	13	4
7. Yellow-grey arenaceous clay	11	0
8. Greyish arenaceous clay in which stratification is scarcely apparent	71	4
9. Yellowish sandstone, thin bedded	2	0
10. Grey arenaceous clay	4	5
11. Purplish shale	1	6
12. Grey arenaceous clay	5	6
13. Brown shale, with imperfectly preserved plant remains	0	6
14. Grey arenaceous clay	14	8
15. Purplish shale, with some thin layers of impure lignite	8	10
16. Purplish-brown shale	1	0
17. Greyish arenaceous clay	7	7
18. Grey arenaceous clay, upper part shaly	11	1

	Feet.	Inches.
19. Yellowish arenaceous clay	4	5
20. Purplish shale	1	0
21. Yellowish arenaceous clay	8	11
22. Purplish shale	2	2
23. Greyish arenaceous clay	6	9
24. Sandstone, a few inches.		
25. Greyish arenaceous clay	4	6
26. Yellowish arenaceous clay (lowest bed in which remains of molluscs were found at this place. *Ostrea*)	4	5
27. Nodularly hardened sandstone	1	0
28. Yellowish arenaceous clay	31	0
Concealed in slope to river, about	30	0
About	284	10

Thickness. "The thickness of beds displayed in the above sections, when combined, is about 375 feet, and the bottom of the river-valley is, probably not very far above the base of the Lignite Tertiary formation. It will be observed that the genus *Ostrea*, is here for the first time mentioned as occurring in these beds; further west it becomes one of the most usual forms. The conditions of deposit implied by the beds on the Milk River, are those of an estuary, or shallow sea margin, where, while oysters and corbulas were living, the remains of fresh-water shells and land vegetation, were being carried and mingled with them."

Conditions of deposit.

"The superposition of these beds on the Cretaceous clays of group 4, is not clear in this locality, as no junction of the two formations was observed. Their lithological character, might almost seem to render it probable, that they represent the same series as that supposed to come up from below the Cretaceous clays between the East and West Forks of Milk River."

Correlation of beds.

Supposition confirmed. This latter supposition has been confirmed by the work done since the above description was written, as the rocks shown in the valley of Milk River have been traced northward to Many Berries Creek, and from thence on to the head waters of Sage Creek, at which point they are plainly seen to be overlaid by the Fort Pierre shales.

The plains between Milk River and Many Berries Creek, near the international boundary, have a heighth of about 2,900 feet, but going north towards the south-west corner of the Cypress Hills, the elevation rapidly increases, and near the base of the hills it exceeds 4,000 feet. A few miles north of Many Berries Creek, proceeding in a northerly direction, the edge of a low plateau running north-west and south-east is reached. This plateau had been deeply gashed in many places along its south-western slope by coulées running back from Many Berries Creek and cutting deeply into the soft argillaceous and arenaceous

Elevation of Plains.

Low plateau.

rocks of the Belly River series, which constitute its principal mass. Near the summit of the plateau, at an elevation of about 3,000 feet the Belly River series is overlaid by the Pierre shales. The superposition of the Pierre on the Belly River series is clearly seen in many of the sections along the edge of the plateau, especially on those occurring on the branches of Sage Creek. This stream heads in the plateau, in which its numerous branches have carved out a deep bay, and flows south-eastward, crossing the forty-ninth parallel a few miles east of Wild Horse Lake. Near the Line, the banks are low and enclose a wide, desolate clay flat, on which nothing grows except sage-bush and cactus. Farther up, the banks of the valley become higher and sections of rock begin to appear. At one point, this stream has been diverted from its old valley, probably by some obstruction during the glacial age, which has turned it to the east, and it runs for several miles through a narrow valley, with steep-cut banks, before it regains its former channel. The newer valley was probably partly formed by inosculating coulées before it became the bed of the main stream. In its upper part Sage Creek divides up into a number of branches, all of which possess deep valleys and exhibit very fine sections of the rocks belonging to the upper part of the Belly River series and the basal portion of the Pierre shales. North of Sage Creek, the junction of the Pierre and Belly River series is marked by a series of low plateaus facing westward, and extending in a somewhat uneven line in a direction a little west of north to Bull's Head plateau, beyond which point they turn to the east. Sage Creek. Change in course of stream. Junction marked by low plateaus.

The superposition of the Pierre shales, on the more arenaceous and lighter colored beds of the Belly River series, is unmistakably shown in a great number of places along the western slopes of this range of plateaus, and puts the question of the relative position of the two formations beyond doubt. Superposition of Pierre on Belly River series.

East of these plateaus, the Pierre shales become the surface formation, except where overlaid by the elevated Laramie plateaus, and continue so for a great distance; their easterly dip of about 10° to the mile, agreeing very closely with the decline of the whole country in the same direction. Their presence is indicated by numerous exposures in the banks of all the principal valleys and also by the hard clayey and sterile nature of the soil, a feature which nearly always characterizes soils owing their origin to this formation. Dip of shales.

The East and West Forks of Milk River afford good exposures of the shales in the upper parts of their courses, but near the boundary they become concealed by the heavy drift deposits. The drift is, however, almost entirely derived from the underlying shales, and it frequently contains clay-ironstone nodules, and also fragments of the more common fossils of the formation. Exposures on Forks of Milk River.

Belly River series.

The rocks of the Belly River series are brought to the surface, and spread over a limited area, a few miles east of the West Fork in Township 1, Range xxvii, W. 3rd Principal Meridian. They are brought up quite suddenly by a heavy southerly dip from beneath the shales which they underlie conformably. This area was examined by Dr. G. M. Dawson, in 1874, and the following description is quoted from him.*

Heavy dip.

Interesting section.

" A most interesting section occurs in a deep valley about six miles west of East Fork. Exactly on the Boundary-line, the banks show good exposures of the Cretaceous shales, more closely resembling in their lithological character those seen in the upper part of the Pembina Mountain sections, than those of the same beds as occurring in the vicinity of Wood Mountain. The rock is almost, or quite horizontal, is pretty hard, and well stratified, and includes white bands like those already referred to. On following the valley about a mile northward, these clay shales seem to bend suddenly upward and give place to a series of rocks, which appear to underlie them, and which differ from them altogether in character, and include massive layers of sandstone and thick arenaceous clays.

Section.

" A section was measured across the upturned edges of these beds, which is given below, the measurements being reduced, so as to represent the actual thickness of the strata. The section—supposing no reversal to have taken place—is in descending order :—

	FEET.	INCHES.
1. Sombre Cretaceous clay-shales, Division 4, M. and H.		
2. Gray and yellow arenaceous clays, with some remains of *Ostrea* in the lower layers (about)	20	0
3. Greyish-white arenaceous clay, with irregular sheets of ironstone	8	6
4. Carbonaceous shale	1	0
5. Grey arenaceous clay	2	6
6. Black carbonaceous shale	2	0
7. Dark shales, with carbonaceous bands	12	6
8. Carbonaceous shale, with poorly preserved plant remains	1	6
9. Grey arenacous clay	30	0
10. Brown shale, with indistinct impressions of plants, a few inches.		
11. Grey arenaceous clay	3	6
12. Laminated carbonaceous shale, with spots of amber, and impressions of plants	2	0
13. Grey and yellow arenaceous clay	20	0
14. Yellowish arenaceous clay	11	0
15. Grey arenaceous clay	9	0

* Geology and Resources of the 49th Parallel, p. 114.

	FEET.	INCHES.
16. Soft beds — probably yellowish arenaceous clays, but not well exposed	35	9
17. Grey sandstone, weathering yellow, and with many jointage-cracks	12	10
18. Greyish arenaceous clay	45	11
19. Hard sandstone, breaking into large rectangular fragments, and weathering into pot-holes	4	0
20. Soft arenaceous clays	12	10
21. Fine-grained grey-yellow sandstone, with dendritic markings	2	0
22. Grey and yellowish arenaceous clay, with some thin sheets of ironstone	34	5
23. Red-brown sandstone	2	0
24. Soft grey sandstone	6	5
25. Nodular brown sandstone	0	6
26. Soft beds, with some thin sandstone layers	24	0
27. Nodular red-brown sandstone, (about)	3	0
28. Greyish and yellowish arenaceous clays, well stratified, and with small fragments of some Lamelibranchiate shell at the base	88	5
29. Greyish and yellowish arenaceous clays, well stratified	121	10
30. Sandstone	3	0
31. Brownish arenaceous clays, crumbling and rotten where exposed	134	4
32. Grey sandstone (Dip 45°)	1	6
33. Yellowish sandstone, thin bedded and flaggy	34	0
34. Purplish and brownish clays, with evident stratification lines	47	7
35 Impure ironstone	1	0
36. Purplish shaly clays	127	3
37. Impure ironstone	1	0
38. Crumbling earthy clays	26	6
	893	7

"The beds below these are not exposed sufficiently well to enable the section to be measured. From blocks of sandstone strewing the banks, however, it is probable that one or more layers of this rock occur not far below the base, as here given.

"The strike of these beds is N. 27° E. (mag.) and their dip, south-eastward, at angles varying from 45° to about 30°. The tilting of strata to such angles as these—even if the existence of no more violent flexure be suspected—is in itself a circumstance sufficiently remarkable, in a country where, for hundreds of miles, the rocks are found with inclinations no greater than can be accounted for by original irregularities of deposit. The nearest disturbed region is that in the neighbourhood of the Buttes, and the upturning is there in immediate connection with the extrusion of igneous matter."

Tilting of strata, remarkable.

Rocks seldom much inclined.

Age of disturbed beds.

There is little doubt that the upper part, if not all of the beds brought up so unexpectedly in this place belong to the Belly River series. This is shown by their stratigraphical position, and also by their holding at one point numerous specimens of *Corbula perundata*, one of the most characteristic fossils of that formation. Some of the lower beds may belong to the same series as the lower dark shales found north of the Buttes on Milk River. The junction of the Belly River series and the Pierre shales along the southern edge of this disturbed area is clearly shown, but as the northern contact is concealed, it is impossible to say whether the presence of the underlying beds is due to a simple anticlinal swell, or if they are faulted along their northern border, though the latter hypothesis seems the more probable one. In either case, the high angle at which these beds lie is a quite anomalous occurrence in this district.

East Fork of Milk River.

The East Fork of Milk River after leaving the neighbourhood of the Cypress Hills, possesses little geological interest, as the insignificant sections seen along its valley show scarcely anything but drift. An exposure of Fox Hill sands was found at one point, near the extremity of a sharp bend which it makes to the east, about twenty miles north of the boundary.

Range of plateaus.

Old-man-on-his-back plateau.

Proceeding in an easterly direction from this stream along a plain with an elevation of about 3,000 feet, the next point of interest which is reached is the range of low westward-facing plateaus, which extends from the boundary near Range xxiii., W. 3rd Principal Meridian in a north-westerly direction. Old-man-on-his-back plateau, the most northerly member of this range, is about four miles long and about 450 feet high. To the west it presents a steep scarped face, but in all other directions slopes gradually away. Its surface is undulating, and in its highest part very sparingly covered with drift. The beds which enter into the composition of this plateau, are well exposed on its western slope, and are there seen to consist of about 300 feet of Pierre shales, capped by about 150 feet of yellowish Fox Hill sands and sandstone. A few thin beds of nodular sandstone near the top of the Fox Hill have served to arrest the work of denudation, and to preserve the plateau. A range of high rolling hills continues on from the plateau in a north-easterly direction for several miles. South-east of Old-man-on-his-back plateau, and separated from it by a wide valley, is a long rounded ridge much lower than the plateaus either north or south of it, and composed entirely of Pierre. The third plateau, which extends to the boundary, is of more importance than the other two, as it re-introduces the Laramie with its accompanying carbonaceous zone. Good exposures occur along the western face of this plateau. The lowest beds seen consist of Pierre shales of the usual kind. Above these comes the Fox Hill,

Composition.

Rounded ridge.

Boundary plateau.

here about fifty feet thick. This formation looks a good deal greyer than is usually the case, and contains a considerable quantity of hard sandstone in places. The Fox Hill is succeeded conformably by the Laramie, the lower part of which consists of a conspicuous band of white and grey clays and sands, fifty-five feet thick, holding a seam of lignite from two to three feet in thickness. The lignite in this seam is of fairly good quality, and will become valuable for local purposes so soon as the country in its vicinity becomes settled. It has been burnt *in situ* in a number of places along the escarpment. It is overlaid by a bed of dark clay, twenty feet thick, which looks exactly the same as a bed occupying a similar position in the Cypress Hills. The upper part of the Laramie consists of about fifty feet of yellowish and greyish silts interstratified with some thin beds of clay and sand. The Laramie deposits at this point bear a strong general resemblance to the beds occupying the same relative position in the east end of the Cypress Hills and north of Wood Mountain. The surface of this plateau is undulating and near the summit becomes very rough. Towards the east and north it slopes gradually down to the prairie level and no exposures occur. A thick bed of pebble conglomerate was found in a depression a couple of miles east of the west end of this plateau. This bed resembles exactly the Miocene conglomerate of the Cypress Hills, but it probably agrees more closely in age with the more recent deposits of a similar character found south of the "Gap" of the Cypress Hills, and in the valley of the Saskatchewan, which have been referred to the Pliocene. The beds underlying the conglomerate are not exposed but are probably Pierre.

Formations seen in Boundary plateau.

Lignite.

Conglomerate.

Age of conglomerate.

East of this plateau an undulating plain, based on the Pierre shales, but affording no exposures, extends all the way to the White Mud River.

Geology of Wood Mountain.

Wood Mountain is simply a westward projecting spur of the Côteau Laramie area. Its geology is very simple, as the plateau is composed of an undisturbed and conformable series of strata, referable in descending order to the Laramie, the Fox Hill and the Pierre shales. The whole system has a dip in an easterly direction, of about ten feet to the mile.

Wood Mountain. Geology simple.

Dip of system.

On approaching Wood Mountain from the north, along the Moosejaw and Wood Mountain trail, exposures of rock are first met with in the vicinity of Twelve-mile Lake. This lake, which occupies the abandoned channel of some ancient stream, is hemmed in by high banks, which afford excellent sections of all the formations found in in the district. Near its western end, the exposures consist of Pierre shales only, but

going east along the lake, the Fox Hill and Laramie descend successively to its level.

Pierre unfamiliar in appearance.

The upper portion of the Pierre shales, north of Wood Mountain, presents a somewhat unfamiliar appearance, where seen in the sections around the lake and in the numerous coulées leading from the hills, as it has become greyer in colour and more arenaceous than the typical variety, and its foliation is also much coarser. These grey arenaceous shales are occasionaly directly overlaid by the Laramie, but more frequently a varying thickness of coarse-grained, yellowish sandstone, representing the Fox Hill, intervenes between the two. Very few fossils were found in those sandy shales, but one section, after careful examination, in addition to some of the more common fossils of the formation, yielded specimens of *Scaphites subglobosus* and *Anchura Americana*.

Fossils scarce.

Boundary of Laramie.

In the western part of Wood Mountain, the boundary of the Laramie is coincident with the edge of the plateau, but farther east, owing to the easterly dip of the formation, it leaves the hills and turns away to the north, and at Twelve-mile Lake, the plain between it and the foot of the plateau is based entirely on the Laramie. This plain, which has a northerly slope of about fifty feet to the mile, is seamed in all directions by coulées issuing from the hills.

Divisions of Laramie.

The Laramie strata north of Wood Mountain include three somewhat dissimilar groups. At the base there is a series of yellowish sands, silts and clays, holding small interstratified beds of ironstone, part of which may be referable to the Fox Hill. This is overlaid by a very conspicuous band of whitish and greyish argillaceous sands, sands and clays, interstratified with a thick band of carbonaceous shales, which often includes a small lignite seam of inferior quality. This seam has been burnt in a number of places. The third group consists of yellowish silts, sands and sandstones, with an occasional bed of hard nodular sandstone. Although none of the beds in this section maintain the same composition for any distance, and false bedding and other irregularities implying deposition in shallow water, are of frequent occurrence, yet the distinction between the different zones is remarkably persistent, and holds good as far west as Cypress Lake in the Cypress Hills.

Plateau irregular.

East of Wood Mountain Post, the plateau is extremely irregular and broken, a fact due to the multitude of streams and coulées which intersect it in all directions. The banks of most of these valleys are unfortunately, usually grass covered and the geological information they afford is very meagre and unsatisfactory. The few exposures which do occur are very fragmentary and show yellowish and greyish silts, sands and sandstones, belonging to the upper portion of the Laramie. A thick bed of hard sandstone was found near the surface in a number of places and small beds of lignite are of not infrequent occurrence. The

Exposures small.

most valuable seam that was examined is situated about eleven miles east of Wood Mountain Post, in Township 4, Range i., West of the 3rd Principal Meridian. This seam, which has been worked to some extent, is about six feet thick and is of very fair quality. It is associated both above and below with sandy clays. The lignite from this seam was used with satisfactory results by the North-west Mounted Police for blacksmithing purposes, when they were stationed at Wood Mountain. A large stream of cold water collecting on the impervious surface of this bed issues from the bank and pours over its face near the place where it has been worked. **Coal seam.**

Another seam of a workable character was observed a few miles further west in Township 4, Range ii., West of the 3rd Principal Meridian. This seam is well exposed in the side of a hill south of the trail. The following section was measured here :— **Coal seam.**

	FEET.	INCHES.
1. Yellowish sandy clay		
2. Carbonaceous shale		2
3. *Lignite*		8
4. Carbonaceous shales	1	1
5. *Lignite*	4	6
6. Carbonaceous shales	1	0
7. Sandy clays		

Going south from Wood Mountain Post, no exposures of any kind were met with until the southern escarpment of the plateau was reached. At this point, a thick bed of nodular sandstone projects from the slope near its bank, and above it small sections of yellowish silts and sands appear in the bank. **Nodular sandstone.**

The southern edge of Wood Mountain plateau is low, is usually well grassed, and is consequently suffering little from denudation at present. It has been forced back to its present position by the united erosive energies of Poplar River and Rocky Creek. These two streams are still separated by a low diffuse ridge, which is, however, rapidly undergoing degradation. The western slope of this ridge has been worn into bad lands by branches of Rocky Creek which penetrate it in all directions. The sections exhibited in these Bad Lands were examined by Dr. G. M. Dawson in 1874, and the following detailed description is quoted from his report*:— **Bad lands.**

"The most instructive section, however, in the Wood Mountain region, lies twenty miles south of the settlement of that name, on the forty-ninth parallel near the 425 mile point from Red River. Here beds undoubtedly belonging to the Lignite Tertiary formation—which, east **Section south of Wood Mountain.**

* Geology and Resources of the 49th Parallel, pp. 92-103.

of this locality has covered so great an area of country—are found clearly superposed on indubitable Cretaceous rocks. The exposures are numerous, and are produced by the streams flowing from the southern escarpment of the water-shed plateau, above referred to, which has here been gashed by their action into most rugged *Bad Lands.*

Description of bad lands.

"This term has attached to it in the western regions of America, a peculiar significance, and is applied to the rugged and desolate country formed where the soft, clayey Tertiary formations are undergoing rapid waste. Steep irregular hills of clay, on which scarcely a trace of vegetation exists, are found, separated by deep, nearly perpendicular-sided and often well nigh impassible valleys, or, when denudation has advanced to a further stage—and especially when some more resisting stratum forms a natural base to the clayey beds—an arid flat, paved with the washed down clays, almost as hard as stone when dry, is produced, and supports irregular cones and buttes of clay, the remnants of a former high level plateau. Denudation in these regions, proceeds with extreme rapidity during the short period of each year, in which the soil is saturated with water. The term first and typically applied to the newer White River Tertiaries of Nebrasca, has been extended to cover country of similar nature in the Lignite Tertiary regions of the Upper Missouri, and other Tertiary areas of the west. In the bad-lands, south of Wood Mountain, the hills assume the form of broken plateaus; degenerating gradually into conical peaks, when a harder layer of sandstone, or material indurated by the combustion of lignite beds, forms a resistant capping. Where no such protection is afforded, rounded *mud lumps* are produced from the homogeneous arenaceous clays. Waste proceeds entirely by the power of falling rain, and the sliding down of the half liquid clays in the period of the melting snow in spring. The clay hills are consequently furrowed from top to base, by innumerable runnels converging into larger furrows below. The small streams rapidly cutting back among these hills, have formed many narrow steep-walled gullies, while the larger brooks have produced wide flat bottomed valleys at a lower level, in which the streams pursue a very serpentine course. Denudation is even here, however, going on, as from the frequent change in the channel of the stream, it is constantly encroaching on the banks of the main valley, under-cutting them and causing land slips. The method of the immense denudation of Tertiary beds, which is proved to have taken place over the area of the western plains, is explained by the degradation still going on in this way along their present borders.

"The general section at this place, which, though not exposed as a whole at any one spot, is remarkably clear, is naturally divided into four parts. General section

SECTION IN BAD LANDS SOUTH OF WOOD MOUNTAIN.

(The asterisk indicates the horizon at which vertebrate remains were found.)

"Taking first the highest bed seen, the order is as follows:—

"(α) Yellowish sand and arenaceous clay, sometimes indurated in certain layers and forming a soft sandstone. It forms the flat plateau-like tops of the highest hills seen. *About* 50 *feet.*

"(β) Clays and arenaceous clays, with a general purplish-grey color when viewed from a distance. *About* 150 *feet.*

"(γ) Yellowish and rusty sands, in some places approaching arenaceous clays, often nodular. *About* 80 *feet.*

"(δ) Greyish-black clays, rather hard and very homogeneous, breaking into small angular fragments on weathering, and forming earthy banks. About 40 feet seen.

"The whole of the beds appear to be conformable, and disregarding minor irregularities, are quite horizontal to the eye.

"The clays and arenaceous clays of the upper part of Division β are very regularly bedded, and include a lignite-bearing zone. Three lignite beds, of from one to two feet each in thickness, were observed, but they are separated from each other by rather wide clay partings, and are not pure or of good quality. A bed rich in the remains of plants, immediately overlies the upper lignite. It is composed of a very fine, and nearly white indurated clay, in which the most delicate structures are perfectly preserved. From its soft and crumbling character, it is almost impossible to obtain or keep good specimens; but, in the fragments which were preserved, a few very interesting plants appear. Of these, some are characteristic of the Fort Union group, and identical with those of Porcupine Creek. The association of remains is that of a fresh water pond or lake, and a fine new species of *Lemna* occurs abundantly. Lignite beds. Plant remains.

"In the lower portion of this division, the beds are more sombre in tint, and little differentiated by colour, which elsewhere often renders the stratification apparent. They contain some layers of sand and

sandstone, which show much false bedding and current structure, and sometimes terminate suddenly with abrupt undulations. In some places, sufficient calcareous cement has been introduced among the grains to form hard sandstones, but their thickness is never great, nor do they extend far. Much ironstone occurs in thin nodular layers, and some selenite. About one third from the base of this division a bed was found, in which curious fruits have been preserved, referable to a new species of *Æsculus.**

Fossil fruits.

Vertebrate remains.

"The most interesting feature of this part of the section, however, is the occurrence of the remains of vertebrate animals. They are found exclusively in the lower portion of this division, and most of them below the fruit-bed just mentioned. They are generally closely connected with the ironstone layers, and are often themselves impregnated with that substance. They are also, unfortunately, apt to be attached to the ironstone nodules, or incorporated with them, and traversed by crack-lines, in such a way as to render it difficult to obtain good specimens. A more prolonged search among these hills, than I was able to make, would, however, no doubt result in the discovery of localities where the remains are more abundant and in better preservation.

"Professor Cope has kindly examined the vertebrate fossils obtained in connection with the expedition. Those from this place include fragments of several, species of turtles, scales of a gar-pike, and broken bones of dinosaurian reptiles. Of the turtles, two are new species, to which Professor Cope has given the names—*Plastomenus costatus*, and *P. Coalescens*—and there are portions of species of *Trionyx* and *Compsemys*. The gar-pike belongs to the genus *Clastes*, and of the dinosaurian remains, though mostly too fragmentary for determination, a caudal vertebra resembles that of *Hadrosaurus*.

Fox Hill series.

"Division (γ), the lower series of yellow sands and arenaceous clays, is a much better defined member of the section than Division (α). It is exposed chiefly in the banks of the smaller ravines, but also in the upper parts of those of the main brooks. The nodules which it contains are large and irregular, but often approach more or less closely to a spherical form. They are arranged in horizontal lines in the exposures. No fossils were found in this part of the section.

"The line of separation between divisions (γ) and (δ), is quite well marked by the change in color. The latter shows scarcely a trace of stratification lines. I was very anxious to obtain fossils from it, but succeeded only in collecting a few small fragments. They, however, indicate purely marine conditions; and one of them is referable to the genus *Leda* or *Yoldia*. The identification of the horizon of this bed

Marine fossils.

* *Æsculus antiquus*. The following plants were also found here—*Lemna* (*Spirodela*) *scutata*, *Scirpus*, *Sapindus affinis*, *Trapa borealis*, *Carpolithes*.

does not, however, depend on such slight grounds as these, as it was afterwards traced westward, and found to be continuous with well-marked fossiliferous Cretaceous rocks.

"Divisions (α) and (β) of this section, clearly belong to the Lignite Tertiary. They probably represent, however, merely the lower layers, and differ somewhat in lithological character and arrangement, from those seen at Porcupine Creek, thirty miles east of this place, and at other localities still further eastward. These beds, no doubt, belong to a lower part of the series than is exposed in any of the sections examined between this locality and the Missouri Côteau, and are probably also older than any of those found in the Souris valley. The beds described as occurring on the trail, south of Wood Mountain, belong to about the same horizon, and it is probable that those seen in some places on the Traders' Road, may not be much higher up in the series. It would appear that the conditions most favorable to the formation of deposits of lignite, did not occur frequently or continue long in the earlier stages of the formation in this locality. Correlation of beds.

"Division (δ) being certainly Cretaceous, it only remains to classify division (γ), which is so markedly different in character from the beds above and below it. This bed, I believe, represents group No. 5 of the Cretaceous, or the Fox Hill group of Meek and Hayden. It was frequently observed at other places further west, and its relations will be more fully discussed in the sequel.

"The lignite beds occurring in division (β), have been burned away over great areas in this region. Numerous red-topped hills are seen, the capping being composed of indurated clays and sandstones, often with much the colour and appearance of red brick. The tops of these hills are all nearly on the same plane, and this, if traced back into some of the larger hills and edges of the plateau, exactly coincides with the zone there still containing the lignite. The beds, as there exposed, however, seem hardly of sufficient thickness or importance to cause an alteration of the strata so extensive as has taken place. It is possible from the irregular nature of these deposits, that over the areas destroyed by combustion, the lignite has been thicker and of better quality, and that the fire may have been unable to extend itself into the thinner portions of the bed, where it is separated by clay partings and covered by such a great thickness of other deposits. The combustion must have taken place ages ago, as isolated red-topped buttes now only remain to mark what must have been the level of the plain at that time." Burnt lignite beds.

West of the bad-lands, the Cretaceous rocks are soon brought to the surface by the general easterly dip, and rise rapidly in the plateau. A few sections occur at intervals along both northern and southern slopes, but as they differ in no material respect from those found further east, a Sections west of bad lands.

description of them would only be a repetition of what has already been written.

A ridge of high land connects Wood Mountain with the White Mud River plateau, the summit of which may still be crowned with some lingering remnants of its former Laramie covering, but I was unable to find any sections in which they were exposed.

White Mud River Section.

The rocks shown in the valley of the upper part of the stream, west of East End Coulée, have been described in that part of the report which treats of the Cypress Hills. East End Coulée is a deep wide valley, which runs along the eastern escarpment of the Cypress Hills, and connects a branch of Swift Current Creek with the White Mud River. West of it the river section is upwards of 500 feet deep, while on the eastern side it sinks to about 250 feet, and is composed principally of Pierre shales, with, in some places, a thin capping of Fox Hill sandstones. Further down the Fox Hill sandstones disappear and the banks are composed entirely of Pierre. The valley at this point is about 200 feet deep, and about a mile wide. The Fox Hill sandstones are not long absent, but re-appear in the course of a couple of miles, and are soon followed by the Laramie, the river having entered the White Mud River plateau.

East End Coulée.

The White Mud River plateau is a low diffuse irregular elevation, situated mid-way between the Cypress Hills and Wood Mountain. It is separated from the former by a depression about eight miles wide, but is connected with the latter, by a ridge which flanks the White Mud River on the north for some distance. This plateau has an average width of about twenty-five miles from north to south, and is about forty miles long, but is quite narrow for half the distance. It has a height of about 300 feet above the plains around it, and of 3,375 feet above the sea. Its surface is very rolling, and is broken up by a large number of coulées, most of which are tributary to the White Mud. The edges of the plateau, though sometimes abrupt, are usually very gradual, and are nearly always grass-covered, and as they afforded exposures at only one or two points, the boundaries of the Laramie, as laid down on the map, are based mainly on differences in elevation, and can only claim to be an approximation.

White Mud River plateau.

White Mud River plateau, like most of the plateaus in the district, is composed of Laramie overlying Fox Hill and Pierre. Exposures of these formations are almost entirely confined to the valley of the White Mud River, which cuts across the southern part of the plateau, but the Laramie is also seen at one point in the northern face, where a small

Composition of plateau.

branch of Swift Current Creek has cut back into it. The section in this coulée contains a band of coarse yellowish sandstone, about twenty feet thick, above which comes seventy-five feet of alternating sands and clays, and following this a carbonaceous zone, containing a couple of lignite seams around which the following section was measured:—

	FEET.	INCHES.
1. Greyish, shaly clays	1	0
2. Carbonaceous shale	0	9
3. *Lignite*	1	6
4. Carbonaceous shale	0	0
5. *Lignite*	1	1
6. Yellowish, sandy clays	1	0
	6	4

The thick bed of sandstone in the bottom of the section is probably Fox Hill, on which the plains north of the plateau seem to be based, as exposures of it were found in a couple of places further down on the same valley. **Fox Hill sandstone.**

The Laramie re-appears in the upper part of the banks of the valley of the White Mud, about ten miles east of East End Coulée. A grey band, composed of light colored sands and clays, appears first near the surface and bears a very close resemblance to the rocks occupying the same horizon in the Cypress Hills and like them is overlaid by some carbonaceous beds. Further down, these beds become much darker in color, and contain a larger proportion of clay and also assume a somewhat banded appearance. At this point, the small alternating beds of greyish, yellowish, greenish, and dark colours, give the section a look somewhat similar to the rocks near the base of the Laramie on Little Bow River. This striped band is overlaid by fine-grained yellowish argillaceous sands and sandstones, and rests on the Fox Hill. The sections along this part of the river are very good and show about 250 feet of Laramie beds. The Laramie gradually descends in the banks and reaches the bottom of the valley about twenty miles east of East End Coulée. At this point, the bottom of the section is nearly always concealed by the *talus*, but the few exposures visible seem to show that the beds are horizontal for a short distance, and then dip westward at an angle sufficient to bring them to the surface about eight miles further down; near the angle of a sharp bend which the river makes to the north. Beyond this point, the river runs in a northerly direction for several miles, and follows very closely the edge of the Laramie, exposures of which occur in the western bank of the valley. The eastern bank is lower and shows Pierre and Fox Hill only. The northerly reach of the river is about eight miles long, after which it again turns to the east. Near the bend it is joined by a large coulée which **Laramie. Grey band.** **Dip.**

rises far back in the plateau and shows some very fine sections of the formations composing it. In the banks of this coulée, a couple of miles from its mouth, the Laramie was observed to contain two coal seams each about two feet thick.

Coal seams.

The Laramie is seen in the northern bank of the valley for a short distance below the bend, but soon disappears and is replaced by Pierre and Fox Hill. The valley below this point enlarges considerably, and becomes exceedingly rough, and its scarped banks, in many places, afford sections of Cretaceous strata upwards of 300 feet thick. These sections show a tendency in the Pierre to become lighter coloured and more arenaceous above, a feature which becomes much more pronounced further north. Fossils imbedded in ironstone and calcareous nodules occur in many places, and are usually more abundant some distance down in the formation; the upper part being apparently rather barren.

Sections in valley.

Fossils.

Near the crossing of the trail between Wood Mountain and the Cypress Hills, the banks become somewhat lower and are less frequently scarped, and they often enclose wide clay flats, covered with a heavy growth of *Artemisia*. Below the crossing, the valley continues to bear a somewhat similar character until within a few miles of the boundary, where it encounters a small Fox Hill plateau, and its banks at once become much higher. The following detailed description of the rocks exposed in the valley near the boundary line is quoted from Dr. Dawson*:—

Fox Hill plateau.

"Where the line crosses White Mud River; or, Frenchman's Creek, numerous and very fine exposures of the Cretaceous rocks occur. The stream flows in the bottom of a great trough, cut out of the soft Cretaceous strata, over five hundred feet deep, and in some places fully three miles wide. Many ravines enter this valley from the sides, and numerous land-slips have brought down the upper beds to various levels in its banks, and have produced a rugged mass of conical hills and ridges. The tops of the banks on both sides of the valley are formed of yellowish ferruginous sands, referable to division (γ), of the Bad Land section. They are in many places, hardened into layers of sandstone, and are nowhere very soft. Land-slips have confused the section, but they can be traced in their original position as far up and down the valley as can be seen. I could find no fossils in these beds, though sixty to seventy feet of them must be visible in some places.

Deep valley.

Land-slips.

"Below these are sombre Cretaceous clays of division δ, and they extend downward to the water level of the river; showing a thickness of 273 feet, the base not being seen. The portion of these clay shales most

Thickness of clays.

* Geology and Resources of the 49th Parallel, p. 109.

nearly resembling those last described, and those of the Pembina Mountain series, lies immediately below the yellow sands; below this, to the bottom of valley, they show rather the crumbling earthy character and more sombre-colour of the Bad Lands and Wood Mountain astronomical station exposures. This would tend to prove that rocks like those of the upper part of the typical Pembina Mountain series, are not confined to any particular horizon in the western representatives of that group. About one hundred feet below the base of the yellow sands, a bed characterized by the great abundance of the remains of a fine species of *Ostrea*, occurs. It is referable to *Ostrea patina* of Meek and Hayden; and fragments of a thick *Inoceramus* occur in the same stratum. The Ostreas, for the most part, are quite perfect, and have been entombed where they grew, the valves being still attached. They are frequently roughened externally, and crusted with selenite crystals, produced apparently by the action of acidulous waters on the shell itself."

Comparison with clays in other places.

Fossils.

"A short distance below the *Ostrea* bed, is a zone containing many large septarian ironstone nodules. In some places, a horizontal surface of this bed has been exposed, forming an arid wind-blown expanse of crumpled fragments of the shale, which here and there supports an *Artemisia*, and from which the nodular masses stand up at intervals, as they have been exposed by weathering. The concretions are often as much as twelve or fifteen feet in diameter, and lenticular in form, but are generally broken into fragments by the action of the frost. They hold remains of *Ammonites* and *Baculites*, the former at times two feet in diameter, and referable to *A placenta*, a form, like *Ostrea patina*, characteristic of the 4th group of the Missouri River section. The fossils are unfortunately intersected by the cracks which traverse the mass of the nodules, in such a way as to render their preservation very difficult. Some of them retain their nacreous lustre in all its original perfection. Bleached bands like those already described, occur in many parts of these clays.

Concretionary nodules.

Fossils.

"The beds here appear to be perfectly horizontal, and the increased elevation of the general surface of the country will more than suffice to account for the re-appearance of the yellow sandy deposits last seen in the Bad Lands—without supposing the existence of any gentle anticlinal between the two localities. Our camp, situated a short way down the eastern slope of the White Mud valley, and consequently somewhat below the general level of the prairie, was 445 feet above the Wood Mountain astronomical station, nineteen miles east, by comparison of seven barometric readings at each place. The base of the yellow sands being about 30 feet below the camp, is 409 feet above the astronomical station; and as the base of the same stratum (division γ,) in the Bad Lands section, was found to be about 170 feet above the astronomical

Beds, horizontal.

station, a difference of 239 feet between the same horizon in the Bad Lands and at White Mud River, would remain in favor of the latter. The distance being about thirty miles, gives an eastward slope of about eight feet in the mile."

Easterly dip.

PLAINS NORTH OF THE CYPRESS HILLS.

These plains are partly based on the Belly River series, and partly on the Pierre, but are usually covered so deeply with boulder-clay and other deposits of glacial age, that exposures of the older rocks are seldom seen. The junction of these two formations can be traced with some precision from Bull's Head plateau to near Forbes on the line of the Canadian Pacific railway, but north of that point, it is not again seen until the Saskatchewan River is reached.

Relations of Pierre and Belly River series.

At Bull's Head plateau, Ross' Creek near Irvine station, C. P. R., and a number of intervening points, the superposition of the Pierre on the Belly River series is clearly shown. North of Irvine, characteristic exposures of Pierre holding large calcareous nodules occur, and a thin covering of these rocks may extend north to the Saskatchewan, and connect with the band of dark shales which was observed capping the banks there in one place.

Old water-courses.

A feature of this plain is the number of old water-courses which are found in different parts of it. One of the most remarkable of these commences at Medicine Hat and runs east for over thirty miles, then bends to the north, and continues on into Many Island Lake. At the bend, it is several miles wide, and encloses four small plateaus, which were probably islands at one time. In its lower part, this valley is now followed by Ross Creek, and in its upper part, by Stony Creek, Mackay Creek, and other streams flowing into Many Island Lake. From Many Island Lake, an old channel, which may be an extension of the same system, leads into Bitter Lake and then on to Big Stick Lake. South of Medicine Hat, Big Plume Creek is connected with a branch of Seven Persons River by a wide valley, which seems to be newer than the one now followed by the stream, as its banks are scarped and show extensive exposures of rocks belonging to the Belly River series, while in the present valley the older rocks are entirely concealed by drift.

Sand-hills.

The sand-hills, which cover such a large part of these plains, belong to the upper part of the glacial deposits. They are usually well stratified where undisturbed by the wind. Their material was probably derived from the Fox Hill, and the kindred sandy beds intercalated in the Pierre.

SECTION ON THE SOUTH SASKATCHEWAN, NORTH AND EAST OF MEDICINE HAT.

At Medicine Hat, the valley of the Saskatchewan enters, and traverses for some distance, one of those drift-filled depressions, which so constantly interrupt the sections on all the principal streams. The entrance of a stream into one of these old basins, is indicated at once by the increased width of its valley, as well as by the absence of all exposures of the older rocks. The Saskatchewan west of Medicine Hat is somewhat closely confined by steep rocky banks which force it to follow a comparatively direct course, but east of that point it becomes much more tortuous and continues so until it crosses the pre-glacial hollow. This hollow, which may represent either a portion of the buried channel of some ancient river, or more probably, a lake basin, is of small extent, as going in a northeasterly direction from Medicine Hat, the underlying rocks appear near the bottom of the valley in about eight miles, though they do not rise to any heighth in the banks for eight or ten miles farther. In a southerly direction up Big Plume Creek the edge of the basin is reached in seven miles, and in an easterly direction up Ross Creek in about fifteen. Its extent in other directions could not be ascertained. Drift-filled depressions.

The deposits in this basin are partly glacial and partly pre-glacial. The pre-glacial deposits consist of pebble conglomerate, coarse ferruginous sands filled with small pebbles, silts, and sands, and are very similar in lithological composition and in appearance to the Miocene rocks of the Cypress Hills, from which they were without doubt derived. They are probably of Pliocene age. Deposits in basin.

The glacial deposits, which consist of light yellowish boulder-clay, overlaid in some places by thick sandy beds, have been extensive enough to complete the obliteration of the depression. The boulder-clay is well exposed near the bend of the river, and up the valleys of Ross Creek and Big Plume Creek for several miles from their mouths. In some places it shows obscure lines of stratification. Glacial deposits.

The rocks of the Belly River series which disappear below the Pliocene at Medicine Hat, re-appear about seven miles further down. The exposure consists of dark arenaceous shales overlying greyish sands and sandstone, and underlying unconformably the sands and gravels of the Pliocene. A few miles farther down, the same beds enclose a small coal seam. This seam occurs at the same horizon and is probably a continuation of the seam mined above Medicine Hat. (See Report of Progress 1882–84, p. 77 c.) It is seen at several places between Medicine Hat and Drowning Man's Ford. The most promising exposure occurs about a mile north of the southern boundary of Township Belly River series. Coal seams.

16, Range V, west of the 3rd Principal Meridian; at this point it is about five feet thick, but the quality is very inferior. Between this exposure and Drowning Man's Ford, the section exhibits nothing worthy of much attention. The Belly River rocks undulate near the surface, sometimes rising fifty or a hundred feet above the water-level and then gradually declining until they disappear altogether and for some distance boulder-clay alone with its accompanying beds of silt and sand, appears in the banks.

Wide valley. At Drowning Man's Ford, the valley becomes much lower, and receives from the west a wide shallow and at present little used valley. I was unable to trace this valley up, owing to lack of time. Its existence may be connected with the fact that immediately north of it the river-valley bends away to the east and assumes a much more recent appearance, and it is possible that it may represent a former channel of the river. The character of the valley, after bending east from Drowning Man's Ford, undergoes a marked change; it narrows in to about half its former width, and is confined by bold mural banks often over 500 feet high, which almost seem to overhang the stream. The next thirty miles affords a number of very picturesque views. The cañon is caused by a wide ridge of rocks belonging to the Belly River series which the river encounters and through which it has cut a passage. This ridge, which must have formed a conspicuous feature in the topography of the country in pre-glacial times, has been concealed by the general levelling up to which the country was subjected during the glacial period. It runs north to the Red Deer, which it crosses about twenty miles from its mouth.

Change in character of valley.

Canyon.

Pre-glacial ridge.

Description of Belly River series. The rocks shown in the cañon belong to the upper part of the Belly River series, and consist of pure clays and sands, together with all gradations between the two. They are extremely irregular and no section measured at one place would be applicable anywhere else. In addition to the soft sands and clays, hard beds of greyish and yellowish sandstones are of common occurrence, and more infrequently bands of brown carbonaceous shales, and thin ironstone beds. The sandstones are often nodular, and the coarser varieties frequently exhibit false bedding. The color of the whole section is predominantly grey, but yellowish and brownish tints occasionally prevail, especially towards the top. About four miles below the Rapid Narrows the section is capped by fifty feet of dark shales which may belong to the lower part of the Pierre. These shales continue for three or four miles and then disappear as the banks become lower. For the next twenty miles sections of the Belly River series are almost continuous on both sides of the river, and are exactly similar to those further up, except in evincing a tendency to become somewhat more yellowish in colour.

Dark shales.

Yellower beds.

They are usually covered by a considerable thickness of boulder-clay and stratified sands. At one point, opposite the Middle Sand Hills, the western bank is covered for some distance by a thick bed of blown sand. Near Sandy Point, the beds of the Belly River series become greatly decreased in height in the banks, and are overlaid by 200 feet of yellowish sandy clays and stratified sands representing the glacial deposits. A few miles east of Sandy Point, the western edge of a second pre-glacial basin is reached. The following section, which was measured about eight miles west of the mouth of the Red Deer, shows the character of the beds occurring in it:— Pre-glacial basin.

	FEET.
1. Fine grained sands and silts	65
2. Boulder-clay	10
3. Stratified sands and silts	150
4. Unconsolidated gravel	2
5. Belly River series	175
	402

The gravel bed is more attenuated than is usually the case, but is very persistent and was found wherever the base of the deposit was seen. The sands and silts overlying it are very similar in appearance and composition to the fine grained strata forming the upper part of the Laramie in the Cypress Hills. They are yellowish in color and are usually well stratified. No fossils of any kind were found in them, although they were carefully searched especially on that account, and the position in the later Pliocene to which they have been provisionally assigned, has been given them simply on the strength of their stratigraphical relations. The boulder-clay at this point is of the usual character, but is capped with a somewhat peculiar bed of thinly laminated shale, which is brownish in color and separates easily into thin leaf-like and very elastic laminæ having a dull greasy lustre. Gravel bed. No fossils. Laminated shale.

A few miles above the mouth of the Red Deer, the Belly River series, which have been almost continuously exposed for the preceding seventy-five miles, gradually descend to and then disappear below the surface of the river. The following fossils were obtained from one of the last exposures:—*Physa Copei*, *Unio consuetus*, *Anodonta propatoris*, *Mytilus subarcuatus*. At the Forks, the upper beds of the Pliocene appear near the water level at a number of places, but the greater part of the section is occupied by the boulder-clay, and for the next sixty miles no exposures of any older rocks occur. The break in the section may be due, either to the stream having now regained a former channel, or to its entrance into a pre-glacial basin which has since been filled with Pliocene and glacial deposits. The width of the hollow could not be ascertained, owing to the absence of tributary valleys of Disappearance of Belly River series. Pliocene. Break in section.

any size. The valley of the Saskatchewan east of the mouth of the Red Deer, is seldom less than two miles wide, and is characterized by wide bottoms and easy grass-grown slopes. It affords no geological information of any importance until within a few miles of Antelope Creek, at which point a few small exposures of Belly River sands and clays, were found, scattered at intervals along the bank. These sections, especially towards the top, contain a larger proportion of soft sands and sandstones than is usually the case with this series, and the bright yellowish color of many of the upper beds, gives them a very different appearance, from the almost colorless strata occupying a similar position in the Bow and Belly Rivers country. A number of fossils were obtained from a hard sandstone bed contained in one of the sections. The Pliocene deposits which covered the formation when it sank below the surface west of the mouth of the Red Deer, have disappeared and it is now directly overlaid by the boulder-clay.

Exposures of Belly River series.

Fossils.

A few miles farther down, the river is crossed by what is practically a continuation of the northern escarpment of the Cypress Hills plateau, and its valley becomes at once greatly enlarged. The escarpment is built of Pierre shale, exposures of which, commencing at this point, are of constant occurrence all the way down to the Elbow and beyond. The valley continues to be very deep and wide until it reaches the eastern edge of the Côteau after which it becomes much shallower. Its banks, west of the Côteau, present a somewhat strange appearance, due to the way in which the slope is interrupted by a quick succession of irregularly distributed conical hills, the tops of which are usually black and bare. These hills, which completely cover the surface in many places, are in most cases the results of old land-slips, which have been smoothed and rounded by the action of the atmosphere. Their outline is occasionally broken by small terraces, caused by the superior hardness of some of the beds and by lines of ironstone nodules.

Pierre escarpment.

Strange appearance of banks.

Land-slips.

The shales and associated sandy beds have been so confused, and their relative position so often reversed by the frequent repetition of these slides, that it is almost impossible, notwithstanding the great extent of the exposures, to obtain an accurate section of any thickness. A sufficient number of partial sections was obtained, however, to show that the formation, in this district, is much more arenaceous than usual, and that the shales alternate throughout with thick beds of yellowish sandstone. The following sections which occur near the middle of the formation, will serve to illustrate this fact. It was measured opposite Swift Current Creek, and is in descending order :—

Pierre more arenaceous.

	FEET.
1. Dark brownish shales	20
2. Yellowish and greyish sands, becoming argillaceous near bottom	50
3. Brownish shales, surface covered with crystals of selenite.	50
4. Yellowish ferruginous sands and sandstone, filled with large ironstone nodules	50
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The sandstone bands in this section are filled with fossils, and yielded the following amongst numerous others:— *Placenticeras placenta*, *Baculites grandis*, *Haminea occidentalis*, *Liopistha undata*, *Protocardia subquadrata* et *borealis*. *Cyprina ovata*, *Yoldia Evansi*, *Inoceramus Sagensis* var. *Nebrascensis*, *Gervilia recta*, *Pteria linguiformis* et *Nebrascana*. A number of these fossils have been described as Fox Hill, by Meek, and the fact of their being found here towards the base of the Pierre, together with the occurrence of so-called Laramie fossils in beds which are indisputably sub-Pierre, show, that owing to the wide range of many of the species, little dependance can be placed on the determination of the sub-divisions of the Cretaceous on purely palæontological grounds, at least, in the absence of a full suite of fossils.

Fossils.

Fossils insufficient to determine Cretaceous sub-divisions.

East of the the Côteau the banks of the valley decrease in height, but continue to show occasional exposures of Pierre, as far as the Elbow, where my examination ended.

THE CÔTEAU.

The Côteau constitutes one of the most important topographical features of the central plains. It corresponds with the eastern edge of the third prairie steppe, and is marked by a well defined and permanent rise of several hundred feet in the general increase in elevation of the country to the west. It crosses the boundary in longitude 103° 30′ W. of Greenwich, and then runs in an irregular but unbroken line north-easterly to the South Saskatchewan, which it reaches about thirty miles above the Elbow. The gap, where it is broken through by the river, is about twelve miles wide. Between the north and south branches of the Saskatchewan it is divided up by transverse coulées into several plateaus. At the boundary, the ascent is long and gradual, and scarcely exceeds 200 feet, but there the drift deposits seem to have been piled on the eastern slope, and not on the summit of the Laramie plateau, as is the case further north. At the Dirt Hills, which are situated about half-way between the boundary and the Saskatchewan, the escarpment becomes more abrupt, and has a heighth, according to Dr. Bell, of over 600 feet. North, towards the Saskatche-

Trend of Côteau.

Gradual slope at boundary.

Height.

wan, the heighth decreases again, and at Secretan, on the line of the Canadian Pacific railway, is only 300 feet. The plains, along the base of the Côteau, maintain a general heighth of about 1,950 feet, from the boundary north, in consequence of the northern declination of the country being almost evenly balanced by the increased elevation due to the western trend of the escarpment.

Heighth of plains at base.

Composition.

The Côteau is not dependent for its existence on any particular formation; as the Pierre Fox Hill and Laramie, as well as the glacial deposits, all enter into its composition. At the boundary it consists entirely of Laramie, overlaid by drift, but going north, the Cretaceous appears at its base near the Dirt Hills, and then gradually rises in the escarpment, and near the Saskatchewan, forms almost, if not the whole of its substance. North of the Dirt Hills, the older rocks are usually covered with drift, and in the part laid down on the map which accompanies this report, only three small exposures of Laramie were found. The limits of this formation, had, therefore, for the most part, to be traced out by differences in elevation and are only approximate, as it is possible, that depressions cutting through it, may have existed, which have since been levelled up by the drift. A couple of small exposures were found in the eastern edge of the Vermilion Hills, and north of the river a small detached plateau afforded a section, showing the Cretaceons clays and sands, overlaid by a hundred feet of white argillaceous indurated sands, or soft sandstone, exactly similar to the lower part of the Laramie in Wood Mountain. A small exposure was found south of the Moosejaw and Wood Mountain trail and outside the limits of the map, which is important, as it shews that some, at least, of the kame-like hills and ridges which crown the Côteau, owe their shape, not to accumulations of drift, but to irregularities in the surface of the older rocks. The exposure consisted of light-coloured clays and sands, and was found in the side of a small hill which had the usual aspect of those of the Côteau, and was situated near the highest part of the ridge.

Exposures infrequent.

Important exposures.

Drift deposits.

The drift deposits are poorly exposed in that part of the Côteau examined by me, and seem to consist simply of boulder-clay overlaid by irregularly stratified sands and gravels. The deposits are not distributed uniformly, but thin out in higher parts of the plateau like that between the South end of Old Wives' Lake and the Dirt Hills.

The Côteau an old sea margin.

That the Côteau formed the margin of an ancient sea, is rendered highly probably by its extent and uniformity, its independent course, and the generally even heighth of the plains along its base, although all direct evidences of the fact, such as terraces and raised beaches have long since necessarily disappeared, and have been either destroyed by denudation or buried under the drift.

The Eyebrow Hills, which are situated near the head waters of the Qu'Appelle, may be regarded as an outlier of the Côteau. They project about 100 feet above the undulating plains around them, and are composed of the arenaceous upper part of the Pierre or Fox Hill. They are covered in one place by small sand-hills, the material of which has been obtained directly from a disintegrating bed of soft sandstone, which is plainly exposed to view. The drift deposits on these hills are very thin, and are represented in some places by a few scattered boulders only, a somewhat remarkable circumstance, in view of the fact, that the hills have been selected by a prominent glacialist, as one of the resting places of his continental glacier. The drift deposits also become very thin over parts of the plain lying between the Eyebrow Hills and the foot of the Côteau; and at one place along Thunder Creek, the surface was observed to be underlaid for some little distance by the Cretaceous clays. It is possible, however, that in this and in similar cases, the drift may have been removed by denudation. East of the Eyebrow Hills, an escarpment about 200 feet high, faces eastward and runs for some distance parallel with the Qu'Appelle valley.

Eyebrow Hills.

Sand-hills.

Drift deposits.

GENERAL GEOLOGY.

The following table includes all the formations observed in the district:—

Quaternary - -	Stratified sands and gravels. Silts. Boulder clay.
Tertiary - - -	Pliocene (?) South Saskatchewan gravels. Miocene.
Cretaceous - -	Laramie. Fox Hill. Pierre. Belly River series.

Belly River Series.

The Belly River series is represented by its light-colored upper division which is distributed over a large area in the north-western and south-western parts of the district. It is well shown in the cañon-like part of the Saskatchewan between Medicine Hat and the mouth of the Red Deer, where almost complete sections can be obtained, and also in the valleys of Milk River and Many Berries Creek, and at Bull's Head plateau, Ross Creek, and numerous other places along its eastern boundary.

Distribution.

Character.

The general character of the formation is remarkably constant, although individual beds are subject to rapid changes in composition and texture, and the following description of the formation, as observed in the Bow and Belly Rivers district by Dr. G. M. Dawson, is equally applicable here. (Report of Progress, 1882-84, page 116 c.)

"It is composed for the most part of sandy clays, with shales and sandstone, the latter often of considerable thickness, and usually rather soft or irregularly hardened. Layers of ironstone nodules, which are at times very large, are of frequent occurrence, and the beds generally have a characteristic bluish- or greenish-grey tint, and are, on the whole, rather massive and weather easily into bad-lands. In these features, with the occurrence of rolled clay pellets and the rounded character of many of the included bones, there is evidence of a considerable amount of current or wave action."

In addition to the varieties mentioned above, beds of yellowish nodular sandstone attain considerable importance in some of the sections, and are frequently found capping the formation. The distinctive pale color which is so characteristic of the series as a whole from Medicine Hat west, is replaced towards the north-east, to some extent at least, by more yellowish tints. The change was first noticed in the sections around the Rapid Narrows on the Saskatchewan, but becomes more evident farther down the river.

Stratigraphical position.

The doubt which existed at one time in regard to the stratigraphical position of the Belly River series, on account of the Laramie *facies* of its invertebrate fauna, has been removed by a more complete examination of its eastern margin. Its line of contact with the Pierre has now been traced, through a distance of over 150 miles, by numerous exposures, all of which afforded the clearest possible proof of its subordinate position. The junction is marked in many places by low plateaus (see p. 41), which offer exceptional facilities for noting the relations of the two formations, as they owe their origin directly to the superposition of a protecting covering of the less easily eroded dark shales on the light-colored beds below. The western slopes of these plateaus are usually bare, and the line of contact between the two dissimilarly colored series distinctly drawn. A reference to the general section which accompanies the map will also show that at the west end of the Cypress Hills, the Laramie and Belly River series separated by the Pierre shales, occur in what is practically the same section, and as the beds have been so little disturbed, that their maximum dip seldom exceeds ten feet to the mile, and consequently no question of overturn or dislocation is involved, no better stratigraphical evidence can possibly be offered.

T. C. Weston, Phot., June 21, 1884. Artotype—Canada Bank Note Co., Montreal.

BANKS OF ROSS CREEK VALLEY, NEAR IRVINE STATION, CANADIAN PACIFIC RAILWAY.

SHOWING BELLY RIVER SERIES CAPPED BY BASE OF PIERRE SHALES.

The following fossils were collected from this series in different parts of the district embraced in the report, and are all from the upper or pale-colored division of the formation:— Fossils.

Ostrea glabra. Meek and Hayden.
Ostrea subtrigonalis. Evans and Shumard.
Mytilus subarcuatus. Meek and Hayden.
Anodonta propatoris? White.
Unio primævus. White.
Unio consuetus. Whiteaves.
Sphærium formosum? Meek and Hayden, var.
Corbula subtrigonalis. Meek and Hayden.
Corbula perundata. Meek and Hayden.
Physa Copei. White.
Viviparus Conradi? Meek and Hayden.

Some of the above fossils, amongst which are *Physa Copei, Sphærium formosum, Ostrea glabra* and *Ostrea subtrigonalis,* are common to both the Belly River series and the Laramie, and their reappearance in the latter after a prolonged absence, during which the Pierre and Fox Hill, —both marine formations,—were deposited, affords an example of the extinction of a fauna over wide areas, its at least partial survival in sheltered localities, and the subsequent re-distribution of some of its members over the same area on the recurrence of favorable conditions. A somewhat similar fact in regard to the Fox Hill fauna has been noted on page 61. Survival of Belly River fauna.

Vertebrate remains occur in every part of this formation, and are strewn in large quantities over the faces of some of the sections. They are however nearly always in a poor state of preservation, and crumble to pieces when disturbed. All the specimens collected, that appeared to be determinable, have been sent to Professor Cope, who has kindly undertaken to examine them. Vertebrate fossils.

THE PIERRE AND FOX HILL.

The Fox Hill sands and sandstones represent the deposits in the shallowing Pierre sea, and as such are necessarily very variable and inconstant. No attempt, has, consequently, been made to describe them apart from the Pierre, and they are represented by the same color on the map. In some places they constitute a definite sandy zone capping the Pierre shales, of variable thickness, seldom much exceeding seventy-five feet, but over most of the district the transition from argillaceous to arenaceous conditions is very gradual, and the two materials either form homogeneous beds of sandy shales, or alternate in separate bands. Fox Hill not separated from Pierre.

Thickness. The Pierre and Fox Hill together, along their western outcrop, have a thickness of about 900 feet. In the eastern part of the district their base is nowhere visible. At the Bull's Head they have a basal elevation of about 3,100 feet above the sea, and on the Saskatchewan, at a point distant 132 miles in a direction N. 50° E., of 1,730 feet, which gives them a general dip in that direction of about ten feet per mile. Dip. Due east they have a dip of only 7·5 feet per mile, and the line of maximum inclination must approximate very closely to the first direction given.

Character. This series covers most of the surface in the eastern part of the district, and forms the floor on which the plateaus are based. It is here, as elsewhere, essentially an argillaceous formation, and is, on the whole, remarkably constant in composition, although usually showing an admixture of more or less sandy material, especially towards the top. On the Saskatchewan sandy beds were found all through the formation. The color of the shales varies from lead-grey to black, and of the included sandy beds from light grey or bluish-grey to bright yellow.

Carbonaceous zone. A carbonaceous zone occurs near the base of the series, and usually carries a small seam of coal, the quality of which is, however, much inferior to that occupying a similar position farther west.

Fossils. Marine invertebrate fossils occur throughout the formation, and are found in great quantities in some of the included sandy beds. The following species were collected:—

Lingula nitida. Meek and Hayden.
Ostrea patina. Meek and Hayden.
Chlamys Nebrascensis. Meek and Hayden.
Pteria linguiformis. Evans and Shumard.
Pteria (Oxytoma) Nebrascana. Evans and Shumard.
Inoceramus altus. Meek.
Inoceramus Barabini. Morton.
Inoceramus Sagensis, var. *Nebrascensis.* Owen.
Inoceramus tenuilineatus. Hall and Meek.
Gervillia recta. Meek and Hayden.
Gervillia recta, var. *borealis (var. nov.)*
Modiola attenuata. Meek and Hayden.
Yoldia scitula. Meek and Hayden.
Yoldia Evansi. Meek and Hayden.
Lucina occidentalis. Morton.
Cyprina ovata. Meek and Hayden.
Protocardia subquadrata. Evans and Shumard.
Protocardia borealis. Whiteaves.
Callista (Dosiniopsis) Deweyi. Meek and Hayden.

Mactra (Cymbophora) Warrenana. Meek and Hayden.
Mactra (Cymbophora) gracilis. Meek and Hayden.
Liopistha (Cymella) undata. Meek and Hayden.
Neæra Moreauensis. Meek and Hayden.
Haminea occidentalis. Meek and Hayden.
Actæon attenuatus. Meek and Hayden.
Cinulia concinna. Meek and Hayden.
Anisomyon alveolus. Meek and Hayden.
Anisomyon centrale. Meek.
Lunatia concinna. Hall and Meek. (Sp.)
Anchura Americana. Evans and Shumard. (Sp.)
Vanikoropsis Tuomeyana. Meek and Hayden. (Sp.)
Baculites compressus. Say.
Baculites grandis. Hall and Meek.
Scaphites abyssinus. Morton. (Sp.)
Scaphites Nicolletii. Morton. (Sp.)
Scaphites nodosus. Owen.
Scaphites subglobosus. Whiteaves.
Placenticeras placenta. DeKay. (Sp.)

LARAMIE.

The Laramie was formerly distributed over the greater part of the district, but has suffered severely from erosion, and is now confined to isolated plateaus, none of which, except the Wood Mountain and Côteau area, are of much extent. It has a general dip towards the north-east of about ten feet per mile, but this is interrupted in a few places by secondary undulations, which are, however, so light as to make it somewhat doubtful whether they are due to the formation having been disturbed or to its deposition on an originally uneven surface. One of these undulations with a synclinal form, striking about N. 70° E., passes through the centre of the White Mud River area, and gives it the appearance of occupying a separate basin, as the summits of the two accompanying anticlines have been bared for some distance, down to the Pierre. Its former connection with the other Laramie plateaus, is, however, distinctly shown by its position, and by the general sequence of its beds. The same fold continues on to Boundary plateau, and has carried the beds there several hundred feet lower than those in the Cypress Hills area in the same general strike.

Former distribution.

Dip.

The Laramie may be separated lithologically over most of the district into two distinct divisions. The lower one, which succeeds the Fox Hill conformably wherever the contact plane of the two formations was observed, bears a strong resemblance to the upper part of the

Lower division

Belly River series, and consists of about 150 feet of feebly coherent greyish and pure white clays, sandy clays, and sands, with occasional beds of carbonaceous shales and lignite. A small bed of black clay was also found to be pretty widely distributed. The beds of pure white sands and clays form the most distinctive feature of this band, and were observed with few exceptions, wherever the base of the formation was exposed. In the bad lands south of Wood Mountain this division consists almost exclusively of clay. The upper division is more arenaceous, and is predominantly yellowish in color. It has a maximum thickness in the district of 750 feet, and is composed of sands passing into soft sandstone, silts and clays, and also holds a few beds of hard sandstone, part of which is of a nodular character, together with some carbonaceous shales and lignite. The whole series is entirely detrital in origin, and shows its deposition in a shallow sea or lake by the irregular and inconstant character of the individual beds, the prevalence of false bedding in all the coarse-grained sandstones, and the existence throughout of coaly seams.

Upper division.

In the west end of the Cypress Hills, the divisions given above do not hold good, and the series there as far as could be learned from the limited exposures, seems to be more argillaceous, and to be characterized by darker colors.

Fossils.

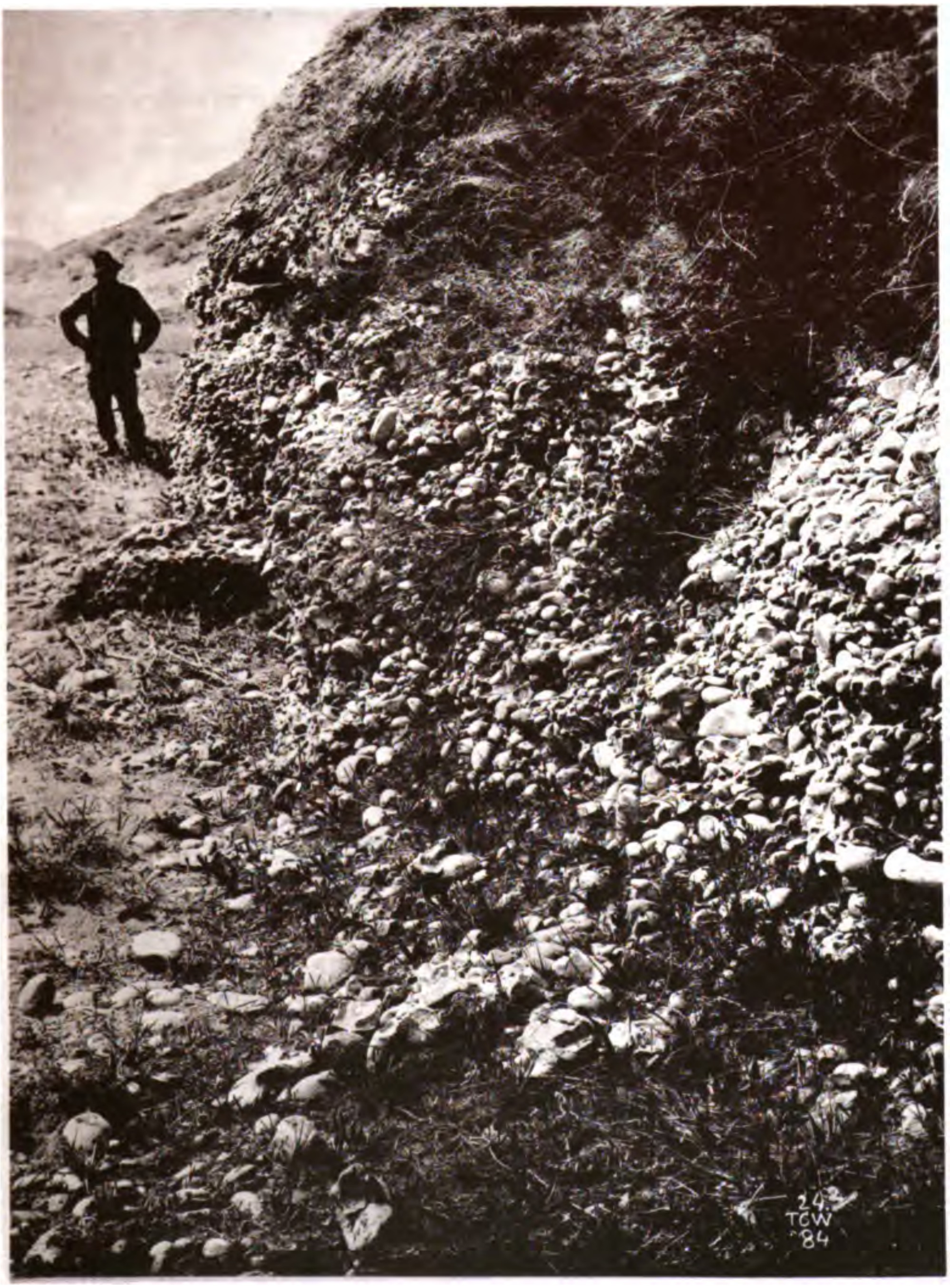
The Laramie in this district, is remarkably deficient in fossils of any value. Silicified trunks of trees are abundant in some localities, and specimens of them, with a few almost indeterminable fragments of leaves and silicified bones, comprise the whole collection obtained from it. A couple of species of fresh-water shells, and some vertebrate remains and fossil plants were obtained in the bad lands south of Wood Mountains by Dr. G. M. Dawson in 1874, and are referred to on page 50.

MIOCENE.

The most interesting result of the geological examination of the district has been the discovery of an extensive area of Miocene beds, the first found in Canadian territory east of the Rocky Mountains. These beds cap all the more elevated parts of the range of uplands extending in a direction a little north of east, from the west end of the Cypress Hills to the east end of Swift Current Creek plateau, a distance of 140 miles. They have an average width of fifteen miles, and cover altogether an area of nearly 1,400 square miles. They are unconformable to the beds below, and, in their western extension rest on the Laramie, but near East End Coulée they overlap it, and are then underlaid by the Fox Hill and Pierre. They have a general easterly dip of about

Extent.

Unconformity.



T. C. Weston, Phot., June 7, 1884. *Artotype—Canada Bank Note Co., Montreal.*

MIOCENE CONGLOMERATE, BONE COULÉE, CYPRESS HILLS.

fifteen feet per mile, which is somewhat greater than that of the underlying beds, and in their eastern part are affected to some extent, by the same depressed fold which has thrown the White Mud River Laramie area into a flattened synclinal form. Dip.

The Miocene beds are characterized by the great quantity of water-worn pebbles, derived from the quartzite formations of the Rocky Mountains, which are found in every part of the series. The pebbles are usually cemented together into massive beds of hard conglomerate, but also occur distributed irregularly through, or arranged in layers and lenticular beds in the sands and sandstones. The more massive conglomerate beds are found towards the western part of the area or around its outskirts. The associated beds, consisting of sands sandstones marls and clays, are described in a previous part of the report (see p. 31 c). They are all very irregular, and seldom remain constant in composition for any distance along their strike. Character.

The area now covered by the Cypress Hills has been changed from a depression in Miocene times into the highest plateau on the plains, which is its present position, entirely by the arrest of denudation over its surface by the hard conglomerate beds which cover it, whilst the surrounding country, destitute of such protection, has been gradually lowered; and so affords an index of the amount of material removed from the neighboring plains in the age intervening between the deposition of the Miocene and the glacial period. The conglomerate capping now overlooks, from a height of fully 2,000 feet, the lowest part of the plains stretching from the western base of the plateau to the mountains, and a line drawn from the summit of the plateau to the average plane at which the present rivers now issue from the mountains would have a mean elevation above the present surface of about 1,500 feet. Such a line however, would not coincide with the Miocene surface, as it inclines westward, while the latter must have risen rapidly in the same direction in order to induce a current powerful enough to urge forward such immense quantities of pebbles and boulders 200 miles from their nearest source. For this work an easterly slope of at least fifteen feet per mile would be required, which would raise the average height of the Miocene surface about 1,500 feet above the line just mentioned, or 3,000 feet above the present surface. This difference in elevation is of course only a minimum one; and would be considerably increased if the supposed Post Tertiary depression of the plains relatively to the mountains was taken into account. Extent of denudation since deposition of Miocene.

The absence of any ridge connecting the Cypress Hills with the mountains is somewhat surprising, as one would naturally suppose that near their source the pebble-beds would be thicker, and their constituents coarser and better able to resist erosion. This may be due, Fossils.

however, to the fact that the valley of the transporting stream must have been more contracted in its upper part than in the dilated portion in which the existing Miocene beds were deposited. In such a case, its narrow shingle floor would be gradually undermined, and, as denudation proceeded would soon perish.

The vertebrate remains obtained from the Miocene beds of the Cypress Hills have been sent to Professor Cope, who kindly consented to examine them, and his report will be found in the appendix.

South Saskatchewan Gravels.*

Under the general name of the South Saskatchewan gravels are included the pebble conglomerates and incoherent gravels and silty beds which are found, as valley or lake deposits, in different parts of the district, and which, although destitute of organic remains so far as examined, are known by their relative position, to be intermediate in age between the Miocene and the Quaternary, and to belong mostly to the period immediately preceding the latter. They are, however, not all contemporaneous, and in one or two places afford evidence by the admixture of Laurentian and quartzite pebbles towards the top, of a gradual blending with the lowest glacial beds. The deposit is usually confined to a single bed of conglomerate, varying in thickness from two up to fifty feet, composed of small quartzite pebbles, precisely similar to those found in the Miocene, and either consolidated by a calcareous or ferruginous cement, or with its constituents lying loose in a sandy matrix. In some places the conglomerate is overlaid by a considerable thickness of sandy or silty beds.

Valley and lake deposits.

Not contemporaneous.

These gravels never rest on the Miocene, but are always found at much lower levels, and in several places, as at Rush Lake Creek and south of the Cypress Hills, have accumulated in valleys skirting the base of the Miocene plateaus. This fact, taken in connection with the lithological identity of the two formations, leaves little doubt as to the derivation of these gravels, in part, at least, from the Miocene. South of the Cypress Hills, they occupy a position fully 1,000 feet lower than the base of the Miocene conglomerate. The small area occurring in a valley in Boundary plateau must have existed there prior to the separation of that plateau from the Cypress Hills by denudation.

Derivation.

Distribution.

In the valley of the Saskatchewan, beds of this age are found underlying the boulder-clay for several miles below Medicine Hat. They

* The name South Saskatchewan gravels has been given to these beds on account of their wide distribution over that portion of the plains drained by this river and its tributaries. They are not however confined to its basin, as they have also been found on branches of the Missouri, of Old Wives' Creek, and of the North Saskatchewan.

disappear soon after the beds of the Belly River series commence to rise in the banks of the valley, and are absent all along the cañon-like part of the river, but are found again near Sandy Point, and are then present as far as the mouth of the Red Deer. At one point, a few miles above the mouth of the Red Deer, the pebble-bed, which is there very thin, is overlaid by 150 feet of fine yellowish sands or silts, on which the boulder-clay rests. East of the mouth of the Red Deer, the river enters an old basin, which may be, and probably is, partly filled with these deposits, but if present, they are buried out of sight below the drift, which is here so thick that none of the valleys, so far as known, have succeeded in cutting through it, and so exposing the subjacent beds. East of this basin, the boulder-clay rests on the Belly River series, and no Pliocene was observed. On Rush Lake Creek and on Boundary Plateau this group is represented by a single thick bed of conglomerate, and in the valley of the East Fork of Milk River, south of the Cypress Hills, by conglomerate overlaid by about fifty feet of fine yellowish sand or silt. A number of angular blocks of a similar conglomerate were found in one place in Wood Mountain, but they could not be traced to their source.

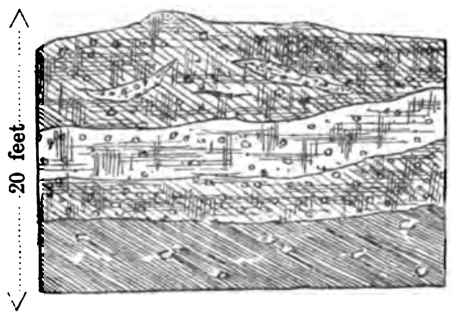
QUATERNARY.

Deposits of glacial age, consisting of boulder-clay overlaid by stratified sands, silts, and gravels, cover the surface of the district everywhere except in the Cypress Hills, west of the Gap. They are very unevenly distributed, and are, as a rule, much thinner on the plateaus and other uplands than in the more depressed areas, though to this there are a few important exceptions, which will be noted in the sequel. **Distribution.**

The boulder-clay, in the northern part of the district, consists of a greyish sandy clay, enclosing numerous boulders, and always becoming more or less yellowish on exposure. It is usually rather hard, and stands up in high cliffs in many places along the different valleys, especially around the convex bends of the enclosed streams. In such cases denudation often proceeds, by angular fragments separated by shrinkage cracks falling away from the face of the cliff, which is, consequently, soon buried behind its own *débris,* whenever the stream ceases to remove the *talus* at its base. In the southern part of the district, the boulder-clay is darker and more argillaceous, and is mainly composed of the ploughed up and re-arranged material of the underlying Pierre shales. **Character.**

The boulder-clay, in good sections, often exhibits some signs of stratification. Small intercalated beds of sand and gravel are of frequent occurrence in it, and the included boulders were occasionally observed **Stratification.**

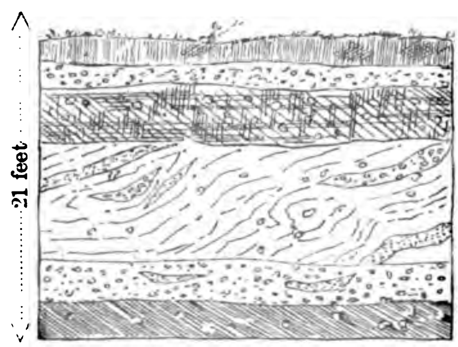
to be graded and to have a more or less linear arrangement. In other places it is divided into different bands, distinguished by differences in color or composition.



Section of boulder-clay on Swift Current Creek.

Corrugated beds.

In a few places, the whole or a part of the section of boulder-clay was observed to be somewhat corrugated, and to be tilted to angles of 30° or more from the horizontal. In such cases the strata were probably disturbed by the impact of an iceberg, although the same effect, according to some writers, may also be produced by the more steady motion of a glacier.



Section of boulder-clay on a branch of Old Wives' Creek.

Commingling of gneissic and quartzite pebbles.

The shingle-bed at the base of the above section belongs to the South Saskatchewan group, and contains a few gneissic pebbles, which must have come from the east, in addition to the ordinary quartzite ores derived from the waste of the Miocene conglomerates. This commingling of gneissic and quartzite pebbles, was however only observed at one other locality, and as a rule, the beds of this group are composed of quartzite pebbles alone. (Compare Report of Progress, 1882-84, p. 141 c.) The lower and disturbed bouldor-clay is similar to the

upper in its color and composition, but differs in its more complete stratification, and in its containing a few sandy and pebbly beds.

Pre-glacial basin.

The boulder-clay attains its greatest development in the district, in the great basin in the older rocks, which extends from a point on the South Saskatchewan a few miles above the mouth of the Red Deer to the Côteau ridge, a distance of about ninety miles. This basin is traversed by the South Saskatchewan, which enters and leaves it by deep cañons cut through the ridges, which, in Pliocene times, formed its eastern and western boundaries. These bounding ridges are, however, unimportant features in the present configuration of the country, as the hollow between them has been filled almost to the brim, and the western one completely buried, by glacial deposits. The thickness of the boulder-clay in this basin can only be ascertained by boring, as it extends far below the surface of the present streams. The thickest sections observed measured about 125 feet. This area of boulder-clay extends north of the Saskatchewan beyond the edge of the map, and south to the northern slopes of the Cypress Hills. South of these hills, it is again met with, and then covers the surface all the way to the boundary. The boulder-clay is also extensively developed in the pre-glacial depression east of Medicine Hat, and in the basin drained by Old Wives' Creek.

Thickness.

Distribution.

Microscopic organisms in boulder-clay.

Three specimens of the boulder-clay from the South Saskatchewan have been microscopically examined by Dr. G. M. Dawson, and the result published in a paper on the "Microscopic Structure of Certain Boulder-Clays and the organisms contained in them," in the Bulletin of the Chicago Academy of Sciences (Vol. I. No. VI.) They were found to contain specimens of several species of Foraminifera together with Radiolarians and other organic fragments, all of which are supposed to have been derived from the underlying Cretaceous rocks.

Drift on plateaus.

The drift on the plateaus consists usually of a few scattered boulders only, but exceptions to this rule occur in the case of the Côteau, the ridge extending north-west from Pinto Horse Butte, and the spur south of the west end of the Cypress Hills, all of which are covered with steep-sided drift-built hills of the ordinary type.

Modified drift.

The stratified sands silts clays and gravels, overlying the boulder-clay have a more limited distribution, and are seldom very thick. The largest section observed occurs on the Saskatchewan, a few miles west of the mouth of the Red Deer (see p. 59 c), and shows about sixty-five feet of fine silty beds or loess. At the Saskatchewan Landing, gravel beds of this age are consolidated into a hard conglomerate. In the plains north of the Cypress Hills the boulder-clay is overlaid by irregular sandy patches, some of which, as the Great Sand Hills, are of considerable extent. An almost continuous line of sand ridges runs

Sandy patches.

along, a few miles north of the Cypress Hills, and extends nearly all the way from Swift Current Creek to the Saskatchewan. These, no doubt, represent sand bars formed near the margin of the glacial sea, when the Cypress Hills marked its southern shore line. The Côteau is fringed in places with a somewhat similar system. The plains south of the Cypress Hills are usually underlaid by boulder-clay only, although some of the valleys, in their upper part, show pebble-beds derived from the Miocene conglomerates which cap the neighboring hills.

Modified drift on Côteau. On the Côteau, irregularly stratified beds of this age cover most of the hills and ridges, and may constitute the entire mass of some of them, and so form true kames, but those well exposed usually show a boulder-clay core. The sections are usually poor, but one or two very good ones, cut through the centre of typical glacial hills, occur near the east end of Rush Lake, and seem to show that the present surface undulations are largely due to irregularities in the old boulder-clay floor, and that the modified drift, over at least part of the Côteau country, wraps both hill and hollow in a nearly uniform sheet, although usually thickening somewhat in the depressions.

Surface boulders. In many parts of the district, and more especially on rough ridges like the Côteau, the surface is often almost covered with gneissic and limestone boulders and angular fragments, which appear at first sight to have been sifted out of the drift below by denudation, and this is, no doubt, true in regard to a large proportion of them. Many of these erratics, are, however, much larger, and are also less water-worn than they would be if derived from that source, and it is highly probable that these represent a more recent period of distribution. One of the largest of these wanderers was dropped south of Wood Mountain plateau, and measures over twelve feet in diameter. Professor Hind mentions one which he saw in the Qu'Appelle valley, near the elbow of the South Saskatchewan, which is seventy-nine feet in circumference. The scattered boulders on otherwise driftless plateaus, like Wood Mountain, Swift Current Creek plateau, and part of the Cypress Hills, may belong to the same period.

Terraces. The only well-marked terrace,—except recent river terraces,—observed in the district, occurs in the Cypress Hills a few miles south of Hay Lake, at a height of 3,700 feet. It is of small extent, and runs along the edge of a dry lake bottom, which is open to the south.

Old channels. One of the most interesting features in connection with the glacial period is the number of old river channels which trench the country in all directions, and which are now either abandoned or hold feeble streams, whose excavating power seems entirely inadequate to the task of ever having carved them out. The Missouri is connected with the

Saskatchewan by two of these old valleys, each a couple of miles wide, which skirt the eastern and western flanks of the Cypress Hills, and tributaries of both systems inosculate in several places with coulées belonging to the now independent basin of Old Wives' Lake. The valley of the Qu'Appelle also continues on to, and interlocks with that of the Saskatchewan, in such a manner as to warrant Professor Hind in inferring that the waters of the latter once flowed eastward through the valley of the former, although contrary evidence of an indirect kind is afforded by the fact that the valley of the Saskatchewan remains unchanged below the mouth of the continuation of the Qu'Appelle valley, and does not assume the cañon character, which, if of recent origin, one would confidently expect.

All the valleys mentioned above may be explained as simply representing the junction of two streams cutting back towards each other from opposite directions. They are, however, all very old, and are evidently the product of an age of much greater precipitation than the present, as they are now undergoing little change. Besides those forming connecting links between the different drainage systems, another class of old valleys is numerously represented, the members of which were excavated for a greater or less distance back from the parent stream, during some former pluvial period, but have since become grass-grown and almost or entirely waterless. **Explanation of changes.**

Some of the old channels in the southern part of the district are due to changes in the courses of the streams, and as such diversions are invariably to the north, they afford further evidence in favor of a recent northerly or north-easterly depression of the plains. An old and partly refilled valley, passing through Stinking Lake, joins the Saskatchewan above the head of the cañon which that river has cut through the Côteau ridge, and as much the same thing has been noted on a previous page as occurring in connection with the cañon between Medicine Hat and the mouth of the Red Deer, it is possible that they may both represent former channels of the stream. **Northward diversion of streams.**

The western part of the Cypress Hills is entirely unglaciated, and must have formed an island in glacial times projecting about 400 feet above the surface, as no drift or other mark of glacial action was observed within that distance of the summit, and as this part has a heighth of about 4,800 feet above the sea, this would give the surface of the glacial sea or glacier, disregarding post-tertiary changes in elevation, a height of 4,400 feet above the present sea level. The Hand Hills are stated by Mr. Tyrrell to be unglaciated above a height of 3,400 feet, and as these hills are situated N. 40° W. from the western end of the Cypress Hills, at a distance of 150 miles, a line connecting the bases of the driftless parts of the two plateaus would **Unglaciated part of Cypress Hills.**

incline toward the north-west at a rate of 6·7 feet per mile, and would have an average elevation above the present surface of about 1,550 feet. Drift was also observed by Dr. G. M. Dawson on the West Butte at an elevation of 4,660 feet, or 1,260 feet above the level at which it disappears in the Hand Hills, which are in nearly the same meridian, and 260 feet above the same point in the Cypress Hills. These differences in level, divided by the differences in latitude of the several elevations, afford evidence of a post-tertiary depression of the plains to the north in this region, relatively to those in the vicinity of the 49th parallel, of about 7·2 feet per mile. The glacial sea or continental glacier is also shown, by subtracting the elevations given above from the present level of the surface, to have had a maximum depth in the plains surrounding the Cypress Hills of 2,000 feet and to have averaged about 1,500 feet.

Post-Tertiary depression.

Depth of glacial sea or glacier.

Economic Minerals.

Comparison with western lignites.

LIGNITES.—The lignites in this district are not so widely distributed, nor do they equal in quality those occurring in the adjoining region to the west, but they are nevertheless found in sufficient quantities to be of great local importance in a region, which, like the one under consideration, is destitute of any considerable forest-clad areas, and will have to depend almost entirely on mineral fuels.

Occurrences.

They occur mostly at three different horizons, viz., at the base of the light-colored upper division of the Belly River series, at the base of the Pierre, and about 100 feet above the base of the Laramie. In the latter, however, the lignites are not confined entirely to one particular zone, but occur more or less throughout the formation.

Seam in Belly River series.

The seam at the base of the upper division of the Belly River series is the one mined near Stair, on the Canadian Pacific Railway. East of Medicine Hat this seam becomes of less importance, and at only two points within the limits of this report was it observed to be of any practical value. References to these will be found on page 57 C.

Seam at base of Pierre.

The coal-bearing zone at the base of the Pierre attains its greatest development near Lethbridge, on Belly River, and then declines steadily in value towards the east, and in this district is represented in most cases, by carbonaceous shales only, although it still contains, in a few places, thin seams of inferior lignite. One of these seams, which outcrops on Ross Creek, near Irvine station, was mined for some time, but the working had to be abandoned on account of the irregular character of the deposit.

Laramie seams.

The Laramie seam underlies the western part of the Cypress Hills, and is exposed in the banks of most of the coulées issuing from the

hills. A specimen of this lignite, obtained from an outcrop of the seam below the old Government farm, near the "Head of the mountain" (see p. 30 C), has been analyzed by Mr. Hoffmann, with the following result:—

Hygroscopic water	16.37
Volatile combustible matter	35.58
Fixed carbon	37.23
Ash	10.82
	100.00
Coke, per cent	48.05

Further details in regard to the quality of this lignite will be found in Mr. Hoffmann's report for 1885, p. 5 M.

In the south-eastern part of the hills, the lignite seams at this horizon are not so well developed, and seldom exceed two feet in thickness. The White Mud River Laramie section includes a lignite-bearing zone, and small seams are exposed at several points along the river, and also in the northern slope of the plateau (see p. 53 C). Boundary plateau is also underlaid by a similar zone. The Wood Mountain Laramie area contains several important seams, references to which will be found on page 47 C, and a detailed description of a typical specimen on page 3 M of Mr. Hoffmann's report for 1885, from which the following analysis is quoted:—

Hygroscopic water	13.73
Volatile combustible matter	36.22
Fixed Carbon	41.23
Ash	8.82
	100.00
Coke, per cent	50.05

The best seams in this region occur east of the area examined.

White band.

CLAYS, SANDS, ETC.—Near the base of the Laramie there is nearly always present a conspicuous white band, consisting of clays, sandy clays, and almost pure white siliceous sands forming a feebly coherent sandstone, which could probably be advantageously used in the manufacture of glass. Mr. Hoffmann furnishes the following description of the clay:—

"This clay has a pale bluish-grey color. It is highly plastic. When burned it assumes a pale brownish-yellow color. It is fusible at a strong

Calcareous nodules.

heat, and could not, therefore, be employed as a fire-clay, but is well adapted for the manufacture of building brick and common clay ware."

CEMENTS.—Material for the manufacture of cements can be obtained from the impure calcareous beds which are found in most of the Pliocene areas, and calcareous nodules occur on Bull's Head plateau, and possibly in other places, in sufficient quantities to make them available for the same purpose.

Clay iron-stone is found in every part of the district, but is too sparingly distributed to be of any practical value.

APPENDIX I.

THE VERTEBRATA OF THE SWIFT CURRENT CREEK REGION OF THE CYPRESS HILLS.

By E. D. Cope.

The collection on which the present report is based, was made by Messrs. R. G. McConnell and T. C. Weston, in the region above mentioned, in the District of Assiniboia, North-west Territory, about Long. 109°, Lat. 49° 40′. The region was first examined geologically by Mr. R. G. McConnell, of the Dominion Geological Survey. He determined the region to be a plateau of considerable extent, consisting largely of beds of shingle, (see p. 31) chiefly quartzitic, and evidently derived from the harder and older rocks of the Rocky Mountain range. The conglomeritic character of the beds accounts for the generally broken condition of the fossils.

Dr. A. R. C. Selwyn, Director of the Survey, having sent the fossils to me for identification, I gave a preliminary list of determinations in the American Naturalist for February, 1885. I then pointed out the fact that the species and genera obtained by Messrs. McConnell and Weston proved the beds in question to belong to the White River or Oligocene epoch. The presence of a genus of well marked Creodonta (Hemipsalodon Cope), was regarded as an indication of a probably somewhat greater age of the bed than that of the typical locality, the White River of Dakota and Nebraska. But the presence of this genus may be yet ascertained in the latter locality.

I now give descriptions of such of the species as are sufficiently represented by material. A large amount of material collected, which remains to be properly correlated with the typical specimens, will add to the value of a complete monograph which I hope to publish by permission of the Geological Survey at a future day. The species are all Mammalia, with the exception of two species of tortoises.

TESTUDINATA.

TRIONYX, sp.—Part of carapace. This genus had not been found in the White River formation, until I detected it in Middle Dakota in 1883.

STYLEMYS, sp.—A few fragments only.

MAMMALIA.

RODENTIA.

PALAEOLAGUS TURGIDUS.—Cope, Report U. S. Geol. Survey Terrs., III. Bk. I., p. 882, Pl. Lxvi., f. 28; Lxvii., 13–27.

BUNOTHERIA.

HEMIPSALODON GRANDIS.—Cope, American Naturalist, 1885, p. 163.

This remarkable flesh-eater is so far only known from the present collection and locality. It also represents a genus not found elsewhere at present, and which resembles, so far as the characters preserved permit us to judge, the Stypolophus of the eocenes, which embraces numerous species, none of which exceeded a red fox in size. Hemipsalodon belongs to the Oxyænidæ, and is the first one of that family that has been found in beds higher than the Bridger Eocene. The species is the largest of the Creodonta, and the jaw from which it is known is more robust than that of any existing carnivore. Its dimensions are about those of the *Achænodon insolens* of the Bridger beds. The genus Hemipsalodon differs from the others of the family in the presence in the lower jaw of the full dental series of four premolars and three true molars without diastema behind the canine. Incisors three. The only crown perfectly preserved is the last true molar. It is of the type of Oxyæna, but probably has no internal tubercle (specimen worn at that point). It has a heel more or less cutting. The species is characterized by the deep compressed form of the ramus, and the long symphysis. The incisor teeth are crowded, and the canine tooth is of enormous size, and is directed upwards. The premolars are all two-rooted, except the first. The fourth is longer than the first true molar. The true molars increase in size posteriorly. The third is very robust, and has elevated cusps, the median exceeding the anterior. The sectorial edges are very steep, forming together a V. The heel is quite short, and has a cutting keel which is the summit of the external face, and is nearly median. The coronoid process rises at a very short distance

posterior to it. The masseteric fossa does not extend downwards to the inferior edge of the ramus. The latter is not inflected on the inner side as far posterior as below the middle of the coronoid process, where it is broken off.

Length of the dental series, M. .212; of true molars .085; of premolars .108; diameters of last true molar: anteroposterior .034, transverse .021; do. of canine at base: anteroposterior .040, transverse .029. Depth of ramus at M. 3, .086; length of symphysis .131.

This species was the largest flesh-eater of the White River Epoch, and the size of its canine teeth proves it to have been a dangerous animal. Its molars are interesting on account of their illustrating the most primitive form of a sectorial tooth.

PERISSODACTYLA.

MENODUS ANGUSTIGENIS, sp. nov.

This large Mammal is represented by numerous specimens. I select for present description two maxillary bones from the same skull, each of which contains the fourth premolar and the true molars; and two lower jaws from second and third individuals. One of these consists of little more than the symphysis. The other includes part of the symphysis, and part of the left ramus, which contains all the molar teeth except the first and last.

I refer the species to Menodus, because both lower jaws have, like the *Menodus giganteus*, Leidy, two incisor teeth on each side. The specimen in which the ramus is present has a small alveolus for the first premolar on each side; the side of the other specimen, where this part is preserved, has no such alveolus. These specimens show the identity of the supposed genus Brontotherium with Menodus. In the contracted shape of its mandibular symphysis this species resembles the species of Symborodon rather than the *Menodus giganteus*, and it resembles the smaller species of Symborodon in its inferior dimensions. It resembles the species of Menodus in the wide internal cingulum of the superior premolars. The species of Symborodon which present this character, are the *S. trigonoceras*, and the *S. heloceras*, Cope. Its measurements are inferior to those of the *S. trigonoceras*, and the superior molars are of different form. In the species just named their outline is oblong, the anteroposterior diameter exceeding the transverse in all three of them. In the *M. angustigenis* the molars are nearly square in outline.

The superior molars of the *S. trigonoceras* are characterized by the flatness of the middle portion of the external face of the external Vs.

This surface is neither excavated, nor is it keeled, excepting a slight convexity on the middle of the anterior V of the first molar. The middle lines of the external faces of the Vs of the fourth premolar are slightly convex. There is a prominent vertical angle descending from the apex of each external V, and no lateral ones, so that there are no lateral pits at the internal base of the V on each side of the apex, as is seen in *Symborodon trigonoceras*. The internal cones of the fourth superior premolar, are not well distinguished. The only traces of cingula on the true molars are just in front of the median external vertical rib.

Measurements of Superior Molars.

		M.
Diameters of P. m. iv.	anteroposterior	.042
	transverse	.054
Diameters of M. i.	anteroposterior	.055
	transverse	.055
Diameters of M. ii.	anteroposterior	.071
	transverse	.066
Diameters of M. iii.	anteroposterior	.071
	transverse	.071

As already observed, the *symphysis mandibuli* is narrowed forwards, and it displays a groove on the middle line between the positions of the alveoli of the canine teeth. The sides of the ramus at this point are vertical, and a little concave above and behind the canine alveolus. In profile the symphysis slopes in an almost straight line from the bifurcation to the incisive border. There are two mental foramina close together. The anterior is the larger, and is situated a little below the posterior, and is below the anterior root of the second premolar.

The inferior canine is of moderate size, and the crown is recurvèd and is somewhat acuminate. The molars are narrow as compared with their length. Their crown consists of the usual two V's, except the anterior part of the second premolar, where the crest is only slightly concave outwards. The first premolar is represented by a single small alveolus. Anterior to it is a diastema a little longer than its diameter. Excepting on the second premolar, the external cingulum is complete and well developed on all the molars; (the last not present.) There is a very distinct, short cingulum at the base of the low anterior one of the three inner cusps, except on the second premolars.

Measurements, Mandibles.

No. I.	M.
Width between canines at exit from alveoli	.027
Length of premolar series	.088

No. II.		M.
Diameters of base of canine.	anteroposterior	.024
	transverse	.023
Length of premolar series		.098
Length of crown of P. m. i		.029
Diameters P. m. IV.	anteroposterior	.038
	transverse	.038
Diameters M. i.	anteroposterior	.050
	transverse	.031
Diameters M. ii.	anteroposterior	.064
	transverse	.041
Depth of ramus at front of M. ii		.086

When the bones of the skeleton in the possession of the survey are studied, a good idea of the proportions of this animal will be obtained. Its dimensions were probably about that of the Indian Rhinoceros.

MENODUS, Sp.

A second and larger species of this genus is indicated by numerous parts of several individuals. One of the most important of these is the superior wall of the skull complete from the end of the muzzle to near the inion, and bearing the lateral horns. This part shows that the species differs from the *Symborodontes trigonoceras* and *acer*, Cope, and the *Menodus ingens*, Marsh, in the absence of angulation above, between the free and other parts of the nasal bones. It also clearly differs from the *S. trigonoceras* in the semi-erect horns with little pronounced triangular section. From the *S. bucco* the lack of expansion of the zygomatic bones distinguishes it. As compared with the *S. altirostris* Cope, it has much longer and wider nasal bones, and the horns are more widely separated. The compression makes their apices anteroposterior, while they are transverse in the *S. altirostris*. In the uncertainty as to how this species differs from the *M. augustigenis*, except in dimensions, I postpone the description until I have access to all the material.

ACERATHERIUM MITE, Cope, Annual Report U. S. Geol. Survey Terrs. 1873, (1875) p. 493. Mandibular rami of two individuals.

ACERATHERIUM PUMILUM, Cope, American naturalist 1885, p. 103. (Name only.)

Portions of mandibular rami of two individuals represent this, the smallest of the Rhinocerontidæ. One of the rami possesses the alveoli of the large recumbent canine teeth, indicating that the species is not a Hyracodon. The molar teeth are unfortunately broken away. The other ramus supports the third premolar, the last deciduous molar, with the first two permanent true molars.

The anterior (? first) premolar has a single large root, with a deep groove on the external side. In the true molars the V shaped crests are fully developed, and there is a low cross-crest at the anterior border of the crown. There is no complete cingulum, but short sections opposite the valley on both the internal and external bases of the crown, on the external side near the front, and at the posterior base. The measurements show how much smaller this species is than the *A. mite*, and that it does not exceed the *Hyracodon nebrascensis*.

MEASUREMENTS.

No. I.	M.
Width between bases of P. m. i	.033
Length of base of anterior 3 premolars	.042
Depth of ramus at diastema	.036
" " " third premolar	.042

No. II.	
Length of molars i and ii	.039
Diameter M. ii. { anteroposterior	.020
Diameter M. ii. { transverse	.012
Depth of ramus at front of M. ii	.033

ARTIODACTYLA.

ELOTHERIUM MORTONI. Leidy.

A superior molar and inferior canine teeth, represent this snilline.

OREODON, or other genus of the Oreodontidæ, is indicated by an inferior first premolar.

LEPTOMERYX MAMMIFER. Cope, American Naturalist, 1885, p. 163, (name only) with question as to the genus.

This species is represented by a fragment of the mandible which supports the last two molars. A tarsal cannon bone in the collection may belong to the same species. It is not certain that this ruminant belongs to Leptomeryx, but I leave it there until further information enables me to make a final determination.

The crowns of the molars are not prismatic nor are they brachyodont. The crown is well distinguished, and expands but little. The sections of the internal columns are lenticular, while the external are crescentic. There are no basal columns or cingula between the latter. In the second true molar, the horns of the anterior internal crescent join the anterior external crescent early on wearing, while the junction

comes later in the case of the two posterior columns. In the third true molar the anterior horn of the posterior crescent does not reach the posterior external column, but only touches the anterior internal column. In the same way, the posterior horn does not reach the external column, but is separated from it by a distinct mammary tubercle or short column, which has an anteroposteriorly short oval section. The heel of this tooth is broken off, but it was small, judging by the fragments of its base.

The peculiar column intercalated between the heel and the posterior internal column distinguishes this species from all the tertiary ruminantia known to me.

The enamel is slightly wrinkled. The half-worn condition of the crowns show that the animul was adult.

MEASUREMENTS.

		M.
Diameters of M. ii.	anteroposterior	.0098
	transverse	.0070
	vertical (of enamel)	.0045

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA
ALFRED R. C. SELWYN, LL.D., F.R.S., F.G.S., DIRECTOR.

REPORT

ON THE GEOLOGY

OF THE

LAKE OF THE WOODS REGION,

WITH SPECIAL REFERENCE TO THE KEEWATIN (HURONIAN ?) BELT OF THE ARCHÆAN ROCKS.

BY

ANDREW C. LAWSON, M.A.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.
1885.

To A. R. C. SELWYN, LL.D., F.R.S.

Director of the Geological and Natural History Survey of Canada.

SIR,—I herewith submit to you my report upon the physical and geological features, and economic resources of a portion of the Lake of the Woods region, together with a geological map of the same, on a scale of two miles to the inch, embracing an area of 72 × 48 miles. The preliminary portion of the work was done in 1883, in which year I was acting under instructions from Dr. Bell, as his assistant. In 1884 the bulk of the work was accomplished, but several weeks from the season of 1885 were required to complete it. To satisfactorily map the field geologically, it was found necessary to make a topographical survey, with micrometer and compass, of all the shores and islands of the Lake of the Woods within the limits of the accompanying sheet. This topographical work was by far the most laborious and time-consuming part of the survey, but has resulted in adding largely to our accurate knowledge of the region altogether apart from the geology, for the elucidation of which the new topography was necessary. I have confined my attention chiefly to the belt of schistose rocks hitherto regarded as of Huronian age, but the distribution of the surrounding Laurentian gneisses has also been determined.

Our grateful acknowledgments are due to Mr. Mather of the Keewatin Lumbering Co., for the loan of certain maps of local surveys, Mr. Matheson and other officers of the Hudson Bay Co., at Rat Portage, for much kind assistance, and to Mr. Dolmage, Mr. Oliver, Capt. Johnston, and Mr. Gibbons for various favours to myself and party.

I have the honor to be,

Sir,

Your obedient servant,

ANDREW C. LAWSON.

Note.—The bearings throughout this report are with reference to the true meridian, unless otherwise stated. The variation is 10° 30′ East.

REPORT

ON THE GEOLOGY

OF THE LAKE OF THE WOODS REGION.

WITH SPECIAL REFERENBE TO THE KEEWATIN (HURONIAN?) BELT OF THE ARCHÆAN ROCKS.

PRELIMINARY REMARKS.

In July, 1883, in accordance with instructions received from Dr. R. Bell, as whose assistant I was then acting, I proceeded to make, in conjunction with Mr. J. W. Tyrrell C. E., and assisted by Mr. F. Cochrane, a geological and topographical survey of the shores and islands of the northern portion of the Lake of the Woods and of Shoal Lake. The method of survey adopted was that whereby the distances are measured with a micrometer telescope in terms of a known base, and the bearings determined by the prismatic compass. The topographical work devolved upon, Mr. Tyrrell, who travelled in a canoe, while I and Mr. Cochrane used a large boat, in which was carried the greater part of our supplies and camp equipment. Mr. Cochrane attended to the management of the discs or base upon which Mr. Tyrrell sighted, while I gave my attention to the rocks, and also made a running compass-survey of the ground covered, as a check upon Mr. Tyrrell's work. About two months only were devoted to this work, and for the rest of the season Mr. Tyrrell and myself were engaged in exploratory examinations elsewhere, Mr. Tyrrell making a track-survey of the route from White-fish Bay to Deer Lake, and I an examination first of the shores the Lake of the Woods from the mouth of the Rainy River to Sabaskong Bay and of Sabaskong Bay itself, then of the chain of lakes between Big-stone Bay and Hawk Lake station, of which I also made a track-survey, and finally of Black Sturgeon Lake. In the short space of time allotted to the detailed work during the first part of the season, little more than a beginning could be expected in the survey of a lake of such tortuous shore-lines, and so full of islands as the Lake of the Woods. The main lines of survey were, however,

Work accomplished in 1883.

Methods of survey.

run and a rapid reconnaissance made of the leading geological features. In 1884, having been placed in charge of a party, in which J. W. Tyrrell and Mr. W. F. Ferrier were my assistants, with instructions to continue the survey of the previous season, I proceeded to Rat Portage and began work about the end of May. The work was carried on, both as regards the geology and the topography, in the same manner as before, excepting that I used another canoe to enable me to more closely examine the shores without delaying the topographical work, and that a Massey's patent boat-log was used in minor surveys, which could be checked by points fixed by more reliable means. Omitting White-fish Bay and the south side of the Grande Presqu'isle, nearly the whole of the shores of the lake, within the limits of the accompanying sheet, together with the contained islands of Shoal Lake, had by the close of the season been carefully examined and topographically surveyed with as much accuracy as the methods adopted would permit.

Progress of examination in 1884.

Fixed points.

For cartographical purposes, fixed points and lines such as the "North-west Angle" of the Lake of the Woods, the various township lines that have been run within the limits of the area, and the railway, served as excellent checks and corrections to the errors incident to a micrometer and compass survey.

In addition to the survey of the Lake of the Woods and Shoal Lake, a number of smaller excursions were undertaken, both with canoe and on foot beyond the basin of the lake, for the pupose of determining the position of various geological lines. And at the close of the season, toward the end of October, I made a hurried run from Turtle Portage to Fort Frances by way of the 'back route,' for the purpose of acquiring a general acquaintance with the Rainy Lake region, which it was proposed to place under survey the following season. While in the neighborhood of Fort Frances, I spent about three days in the excavation of two mounds of prehistoric origin, on the farm of Mr. McKinstry at the confluence of the Little American and Rainy Rivers. I was rewarded by finding a number of relics of bygone oboriginal workmanship, an account of which will be given elsewhere.

Completion of field work.

In 1885, I was instructed to complete the surveys necessary for the publication of the sheet which accompanies this report, and then to commence a similar geological and topographical survey of Rainy Lake. During the season my assistants were Messrs. A. E. Barlow, B.A., W. H. Smith. C.E., and C.S. Morton, B.E. The unfinished work requisite for the Lake of the Woods sheet comprised a survey of the shores and islands of White-fish Bay and a survey of the south side of the Grande Presqu' isle and the off-lying islands. The former task

was successfully completed by Messrs. Barlow and Smith, who found the topographical features of the bay much more intricate than had been anticipated; while the latter was undertaken by myself and Mr. Morton.

The surveys of 1883 and 1884 were plotted and partially mapped by Mr. Tyrrell, who, however, left to take charge of one of the meteorological observatories on Hudson Street. After his departure, the work was continued by Mr. Barlow, upon whom the chief labor of the compilation of the present sheet has accordingly devolved, and to whom credit must be given for whatever excellence the map may possess in a cartographical point of view. Hitherto no systematic attempt has been made to completely map the Lake of the Woods. There have, however, been a number of partial surveys, the manuscripts and printed maps of which have been found of much service in a general compilation. The more important of these that have been made use of in conjunction with our own surveys are as follows:—Joint maps of the North American Boundary Commission published in 1878, which include a map of the North-west Angle Inlet; Russell's map of the Third Base-line as run through to the Iron Bar near Point Dispute with accompanying traverses; Kennedy's map of a group of islands between Yellow Girl Point and Monument Bay; Miles' map of Sabaskong Bay and the south side of the Grande Presqu' ìsle; the Canadian Pacific railway surveys, and the Dominion Lands block outlines. Map. Previous surveys.

The geological work that has hitherto been done on the Lake of the Woods has, like the topographical, been of a rather fragmentary character; and no attempt to systematically study and map the geological relations and structure of the rocks exposed on all its shores and islands has previously been made. It may be well to note what has actually been done in this direction, and refer to the extant geological literature of this field. The following works are mentioned in order of their publication:— Previous geological examinations.

"Narrative of an expedition to the sources of St. Peter's River, Lake Winnipeek, Lake of the Woods, etc., performed in the year 1823, compiled from the notes of Major Long, Messrs. Say, Keating and Calhoun, by Wm. H. Keating, A.M., etc." Keating's expedition.

This gives observations for latitude on one or two islands that cannot now be identified accurately; notes the change in the aspect of the rocks in crossing the old Rat Portage near the present Keewatin station, and makes brief remarks upon the rocks at the few points at which the party stopped in its passage through the Lake.

Paper on the "Erratics of Canada" by J. J. Bigsby, M. D., Quarterly Journal of the Geological Society, Vol. VII. In this, the chief point made as regards the Lake of the Woods, is the fact of the limitation of Dr. J. J. Bigsby

the limestone boulders to the south part of the lake, which the author explains by the supposition that this part of the lake is a limestone basin from which the limestone boulders were derived. He remarks in this connection: "The points to be noticed in the Lake of the Woods are—the abundance of primitive travelled blocks—their northern origin—the total absence of calcareous erratics in the north and the large sand-beds in the southern part of the lake." No observations on the direction of striæ are given.

Paper "On the Geology of the Lake of the Woods, South Hudson's Bay," by J. J. Bigsby, Quart. Jour. Geol. Soc., Vol. VIII, 1852.

In this paper, Dr. Bigsby mentions the various names applied at the time of his visit to different parts of the lake, as follows:—

Names of places.

"Lake of the Woods or Kamnitic Sakahagan."—This is more probably the Indian equivalent of "Island Lake" which was perhaps with more likelihood than "Lake of the Woods," the original Indian name, he present name having arisen by mistranslation.

"Clearwater Lake."—Probably a confusion with the north-west part of the lake known as Clearwater Bay, or with the present White-fish Bay which is still called by the Indians Clear-water.

"Lake of the Sand Hills or Pekwaonga Sakahagan."—From the sand dunes near the mouth of the Rainy River.

"Whitefish Lake or Whitefish Bay."—Only now applied by the Indians to the sheet of water east of the Sioux Narrows.

Geological maps

The paper is illustrated by a map of the lake upon which are represented the author's conceptions of the geology of the region Since, however, the paper was apparently based upon a limited number of observations and was published, as was also the former one, about twenty-five years after those observations were made, it does not afford us a remarkably clear comprehension of the features of the field. It has the credit, nevertheless, of being the first attempt at a geological description of the Lake of the Woods. As regards economic geology, it is stated that "In no part of the Lake of the Woods were any traces of metallic ores discovered, although carefully looked for."

Dr. D. D. Owen

"Report of a Geological Survey of Wisconsin, Iowa and Minnesota," by D. D. Owen, 1852.

The map accompanying this report shows the west side of the Lake of the Woods, from Rainy River to Winnipeg River, colored as a region of metamorphic and granitic rocks, although the explorations of the survey do not appear to have extended to the lake.

"Report on the country between Lake Superior and Lake Winnipeg, by Dr. Bell, in Report of Progress, Geological Survey of Canada, for 1872-3."

On page 104 and 105 of this report, Dr. R. Bell gives notes on the geology of the lake, based on observations made upon a trip from Rat Portage to the North-west Angle. The name Huronian is here first given to the schists of the Lake of the Woods. "The junction of the Laurentian rocks on the north with the Huronian schists of the Lake of the Woods on the south takes place at Rat Portage." And again "In going south-westward from Rat Portage to the entrance of the North-west angle of the Lake of the Woods, a distance of about forty miles, the rocks observed on all the islands consist of Huronian schists, with associated granites." The junction of Laurentian and Huronian is noted as conformable and the probable course of the line of junction, is sketched. A few detailed notes are also given of specific localities observed on the route through the lake. Examinations by Dr. Bell.

The following year, Dr. Bell had occasion to cross the lake from the mouth of Rainy River to the North-west Angle, and in his report for 1873, he devotes a paragraph to recording observations made on the route, the results are regarded as confirmatory of the views set forth in the reports of the previous year.

"Geology and Resources of the region in the vicinity of the Forty-ninth Parallel," by Dr. G. M. Dawson, 1875. Dr. G. M. Dawson's report.

In this work Dr. Dawson devotes a chapter to the geology of the Lake of the Woods, which is the fullest treatment that the subject had up to that time received. He describes in considerable detail the rocks met with along the canoe route from Rat Portage to the North-west Angle, and from that point to the mouth of the Rainy River, by way of the south side of the Grande Prisqu' île and Big Island; and gives a description of the shores of the lake on the United States side of the boundary. The intrusive granites in the vicinity of the mouths of the North-west Angle Inlet, are especially noted, and certain probable generalizations suggested as to their relations to the formations through which they break. The volcanic origin of a large part of the Huronian (Keewatin) rocks is also recognized. The glacial phenomena receive a large measure of attention, the direction of glacial striæ observed along his line of travel being accurately recorded, and interesting notes given on the aspect of the *roches moutonnées* and the character and distribution of the drift.

"On the geology of the Lake of the Woods and adjacent country, by Dr. Bell, in Report of Progress, Geological Survey of Canada, for 1880-82."

Dr. R. Bell gives in this report an account of the most recent work that had been done on the Lake of the Woods, prior to my own. He spent part of the season of 1881 in this region, and in his report for that year gives the results of observations made along the line of the Cana- Report by Dr. Bell.

dian Pacific railway, and in traverses around White-fish Bay, and across the Lake of the Woods, and Shoal Lake, together with other notes not applicable to the field to which the present report relates. The facts which had thus been ascertained by Dr. Bell, in the various explorations made in this county in this and previous seasons, enabled him to publish a preliminary "Geological Map of the Lake of the Woods and adjacent county," to accompany his report, showing approximately the relative distribution of the Laurentian and the "Huronian" rocks of the region.

Reasons for Proposing the Name 'Keewatin.'

Correspondence of Lake of Woods rocks with typical Huronian doubtful.

The belt of schistose rocks which runs through the granitoid gneiss, across the northern parts of the Lake of the Woods has, as above stated, been regarded as of Huronian age. In this report, upon the first detailed investigation of the belt as a whole, I feel it incumbent upon me, at the outset, to say a few words on the nomenclature of the series of rocks comprised within it, and particularly to question the advisability, in the light of recent investigations, of relegating these rocks to a position stratigraphically and geognostically equivalent to the typical Huronian of Sir William Logan, as described in the Geology of Canada, (1863). It must always be an extremely difficult matter to demonstrate the equivalency or non-equivalency of any two widely separated sets or series of Archæan rocks, devoid of fossils. Lithological similarity has by no means been established as a criterion of geological equivalence, except in a very general way, of little or no value in specific comparisons of given series of rocks. On the other hand, it seems reasonable to suppose, (and indeed the rocks themselves establish the fact), that volcanic activity played a much more important part in the development of the formations of Archæan times than in that of later geological ages; and farther, since these volcanic rocks were mixed with ordinary aqueous sediments, and the volcanic action was intermittent and irregular, we would expect to find series of the same geological age, of all gradations of lithological character, from an almost wholly volcanic to an almost wholly sedimentary composition. Thus the extreme dissimilarity of series so composed would be no proof of geological disparity. Lithological character is only one of several considerations that must be taken into account in a question of the corelation of two geological series geographically separated.

Lithological characters uncertain criteria.

Points of difference from typical Huronian.

The schistose belt of the Lake of the Woods appears to me to differ from the typical Huronian of Sir W. Logan, both lithologically and in other respects. The typical Huronian of Logan is, from his description

of it, essentially a quartzitic series, in which the quartzites are true indurated sandstones.* The schistose belt of the Lake of the Woods is not so characterized. Quartzites form an extremely small proportion of the rocks of the Lake of the Woods, and then they are only local developments in formations of mica-schist and felsite-schist. Bedded limestones are characteristic of Logan's typical series. On the Lake of the Woods there are, so far as I have been able to determine, no bedded limestones, the nearest approach to them being small segregated bands of dolomite, of the character of vein-stones. These two differences alone are sufficient to throw doubt on the equivalence of the two series, if lithological character is to be regarded as an aid to geological classification. There are, however, other differences. The basal conglomerate of Logan's Huronian, on Lake Temiscamang, is described as "holding pebbles and boulders, sometimes a foot in diameter, of the subjacent gneiss, from which they appear to be derived. The boulders display red orthoclase feldspar, translucent, colourless quartz, green hornblende and brownish-black mica, arranged in parallel layers, which have a direction according with the attitude in which the boulders were accidentally enclosed." The rocks on the Lake of the Woods, which are in the following pages referred to as "agglomerate-schists," are not basal conglomerates. They are not at the base of the series included in the schistose belt, nor are they apparently composed of water-worn fragments, derived from the rocks upon which they rest.

Quartzites unimportant.

No true basal conglomerate.

No fragments that can be referred to the underlying granitoid gneisses are found included in the agglomerate-schists of the Lake of the Woods. All the facts connected with them point to a volcanic origin for these agglomerates†, and the fragments are very frequently sharply angular, often with re-entering angles, although, for the most part they are elongated and lenticular in shape as a result of pressure, and the paste in which they are imbedded does not differ from them materially in composition as a rule. In rare instances they pass into pebble- or boulder-conglomerate, in which the pebbles are usually of a reddish felsitic material and indicate the co-existence of aqueous, with volcanic deposition.

Fragmental rocks of volcanic origin.

The "green slate rock" conglomerates at the mouth of the Doré River, Lake Superior, described by Sir W. Logan, supposed by him to

Resemblance to Doré River series and remarks on this.

* Preliminary Paper on an Investigation of the Archæan Formations of the North-Western States. by Roland D. Irving (Extract from Fifth Annual Report of U. S. Geological Survey,) pp. 230, 236.

† Dr. G. M. Dawson, speaking of these rocks says: "The conglomerate rocks have, as a whole, much the aspect of volcanic breccias, such as those found in association with the older Silurian series in Wales and Cumberland; and volcanic action would appear to offer the most reasonable explanation of their origin and distribution." Geol. and Resources, Forty-ninth Parallel, p. 52.

be equivalent to the rocks of his main Huronian area, appear to resemble the agglomerate-schists of the Lake of the Woods. This Doré River area of "green slate rocks" is, however, geographically distinct, and appears to differ from the series in the typical Huronian region. The rocks are described as standing in a nearly vertical attitude, while those of the latter are comparatively flat. Neither are they associated with beds of quartzites or limestones to a material extent. Those differences, with the geographical separation, may, I believe, warrant us in considering the possibility of Logan having embraced under one designation two distinct series, and in regarding as Huronian, for the present, at least, only his main Huronian area, which is mapped in detail.

Basal rocks on Lake of the Woods.

As a general rule the basal member of the schistose series of the Lake of the Woods is a group of black hornblende-schists with associated trap-rocks, principally altered diabases and diorites. In Logan's Hurorian, this formation appears to be wanting in this stratigraphical position, or finds its analogue in "a mass of rather coarse-grained greenstone or diorite, usually interposed between the Laurentian gneiss and the recognized Huronian rocks, on the Sturgeon, Wahnapitae, and White-fish Rivers; but whether this is an overflow constituting the base of the upper formation, or an eruptive mass in the form of a dyke intruded at a later period, has not been ascertained."

Mica-schists, hydromica-schists and clay-slates appear to be but sparingly, or not at all represented in Logan's typical Huronian series. In the Lake of the Woods belt they are extensively developed and form an important constituent of the series.

Main point of resemblance to typical Huronian.

There is, however, one point of resemblance. In Logan's series there is 2,000 ft. of "chloritic and epidotic slate, interstratified with trap-like beds." In the Lake of the Woods belt, there is abundance of chlorite. The hornblende-schists, diabases and diorites are generally very much decomposed, and the rocks are as a result largely chloritic. In addition to this, there are formations—particularly interbedded with the hydromica-schists—of soft, finely fissile, green schists, which appear to be altogether chloritic.

In the face of so many important points of difference, I hesitate to believe in the equivalency of the two series, although quite prepared to admit the possibility of two series of geologically the same age having widely different lithological characters in geographically separate regions.

Period of flexure and granitic intrusion.

There are, moreover, other considerations. There are two conditions which appear to be generally characteristic of the Laurentian gneisses of North America:—1. They are sharply folded. 2. They are cut by intrusive granites. Now the Lake of the Woods belt of schists

is folded with the granitoid gneisses and is cut by several very large masses of granite and many smaller dykes. That is to say, the present schistose rocks of the Lake of the Woods were laid down upon the granitoid Laurentian gneisses, whatever may have been the original form of these, before the main era of folding was inaugurated and before the granites (probably as a concomitant of the folding) were forced up from below. It is extremely doubtful that this is true of Logan's Huronian series, from his description of it. The series is flat-lying or gently undulating, and its basal member contains "boulders of the subjacent gneiss, from which they appear to be principally derived."

Relation of granite intrusions to typical Huronian.

Further, Logan's mapped area of Huronian is not characterized by the presence of large masses of granite, although in the immediate vicinity of one part of this area "the intrusive granite occupies a considerable area on the coast of Lake Huron, south of Lake Pakowagaming. It there breaks through and disturbs the gneiss of the Laurentian series, and forms a nucleus from which emanates a complexity of dykes, proceeding to considerable distances. As dykes of a similar character are met with intersecting the rocks of the Huronian series, the nucleus in question is supposed to be of the Huronian age, as well as the greenstone dykes which are intersected by it."* Similarly, just beyond the northern border of Logan's Huronian area, "cliffs of syenite and granite" are recorded as observed on the Mississague River, although none are stated to cut the Huronian strata in the neighborhood. Logan does not state in so many words that the underlying gneisses are folded, but both on his map, by the plotted dips, and in his sections 1 and 1 A,† he shows that such he conceived to be their condition.

Points of difference.

It thus appears that while the Lake of the Woods schists are older than the time of folding and older than the granites which are intruded through them, Logan's typical Huronian has come into existence later than the time of folding of the gneiss and possibly also later than the main period of granitic irruption. If then we suppose, as there is every reason for doing, that the time of folding of gneiss and irruption of the granite was in a general way the same over this portion of the continent, we have the Huronian series and the Lake of the Woods series at once relegated to two very distinct geological ages.

Views of Prof. R. D. Irving.

The investigations of Prof. R. D. Irving, of the United States Geological Survey, have a further direct bearing on the question and afford an approximation to direct stratigraphical evidence. One result of his labors, which have extended over several years, is the con-

* Geology of Canada, p. 58.

† Atlas, 1865.

clusion which he has arrived at that the Animikie series of Thunder Bay is identical, lithologically and stratigraphically, with Logan's typical Huronian. He establishes the lithological similarity of the two series; points to the fact that both series are comparatively flat-lying and demonstrates the relations of each to gently folded or undulating series of rocks of similar lithological character, viz: the Marquette, Menominie and Penokee-Gogebie series, on the south side of Lake Superior, to which they appear to be equivalent, and which constitute a geographical chain of connection between them. If, then, the Animikie and Huronian are identical, as Logan himself believed as regards a portion at least of the Animikie, what are the relations of the folded schists of the Lake of the Woods to that flat lying series. This is a question still to be answered. Prof. Irving has expressed the opinion "that both the flat lying Animikie slates and the more northern folded iron-bearing schists are Huronian," and gives a diagram to shew the hypothetical identity of the folded and unfolded series on either side of the Mesabic range of granite and gneiss.*

These rocks do not represent the Animikie.

The folded schists to the north-west, however, so far as the Lake of the Woods series teaches, are as different from the Animikie as they appear to be from the typical Huronian, and were probably folded with the gneisses before the Animikie rocks existed as such. The Animikie series rests apparently on granite along part of its western confines. The granite of the region appears, as is known to have been the case in the Lake of the Woods, and has more recently determined to be true also for Rainy Lake, to be of later origin than the folded schists. Hence, in the superposition of the Animikie rocks upon the granite, we have again a sharp distinction in geological time between the Animikie (Huronian?) and the folded schists to the west, as represented by the Lake of the Woods series.

"So-called Huronian."

In the "Geology and Resources of the Forty-ninth parallel," Dr. G. M. Dawson refers (p. 50) to the Lake of the Woods rocks as "so-called Huronian," and points out (p. 52) their resemblance, first to the Hastings series (then described as Laurentian) and second to the rocks of the Quebec Group, at the time supposed to be much newer than the Huronian.

The name Keewatin proposed.

In view of the above facts, it seems expedient that this series of rocks should receive a convenient name, which shall be non-committal as to geological relations, and which may be used provisionally till such time as those relations are established beyond question. The most appropriate name for the series that suggests itself to me is "Keewatin," the Indian name for the North-

* Third annual report U. S. Geol. Survey, pp. 170-171.

west, or the North-west wind, which has been applied to the district within which the rocks occur. If the series should in future be definitely correlated with the Huronian of Logan,—or any other known and described series,—the name can be dropped, while, should it prove of permanent utility for purposes of geological classification, it may be retained.

The rocks so designated on the Lake of the Woods may be taken as representative of an important division of the Archæan, extensively developed in parts of the great Laurentian area, but here first investigated in detail.

RELATION OF PHYSICAL FEATURES TO GEOLOGICAL CONDITIONS.

Two parts of the lake.

The Lake of the Woods is naturally divided into two distinct parts, having strongly marked differences in their physical aspects. These may be referred to as the northern and southern portions of the lake. The northern portion has an excessively irregular, rocky coastline, and its whole expanse is thickly studded with islands, varying in size from mere rocky islets to masses of land many miles in extent. The southern portion presents the contrasting character of a broad sheet of shallow water, almost totally free from islands, contained by low, sandy or marshy shores of gently sinuous outline, in which rock exposures are extremely few, the whole in remarkable opposition to the jagged cliffs and tortuous island-blocked channels of the northern portion.

Line of demarkation.

The line of demarkation between these two naturally distinct portions of the lake is nearly coincident with the international boundary line from the North-west Angle to the mouth of the Rainy River, were that line to bend round so as to pass the southern extremity of Bigsby Island and strike the main shore at the mouth of Little Grassy River, it would separate as nearly as possible the two portions of the lake thus characterized.

The northern portion of the lake occupies a short, broad belt of green, schistose Archæan rocks which have hitherto been referred to as Huronian. The southern portion appears to be wholly in a basin of Laurentian gneiss, the flanks of which pass beneath the drift on the Minnesota shores to the south and west.

In the northern portion of the lake, sand-bars and deposits of the finer kinds of drift are in general rare. In the southern, sandy beaches characterize the coast, and in the neighborhood of the mouth of the Rainy River, extensive spits or bars of sand have accumulated for many miles, upon which the wind has blown the loose dry sand into conical dunes, which seem at a distance to have a picturesque resemblance to a collec-

tion of Indian wigwams, and have given rise to the name of "The Lake of the Sand Hills" which is sometimes applied to this portion of the lake.

Drainage area. The lake forms a basin or reservoir for a drainage area of 36,000 square miles, half of which is on the Canadian side of the boundary. A considerable proportion of the water from this area drops in from small streams draining lakes near to the main lake, but by far the greater part finds its way to the lake by the Rainy River, the embouchure of which is at the extreme south-east of the lake. The waters of

Outlet. the lake are poured into the Winnipeg River, over the two beautiful falls on either side of Tunnel Island, near Rat Portage, at the extreme north end of the Lake. Both of these falls, the more easterly of which, from its beauty, may be called "Hebe's Fall," and the other the "Witch's Cauldron,"* present magnificent opportunities for the utilization of an inexhaustible motor power. In several parts of the lake there is a strong northerly current which gives it in these places the character of a river.

Limits of map. The greater part of the northern portion of the lake is included in the sheet accompanying the present report. The limits of the sheet are latitudes 49° 11′, and 49° 53′ north, and longitudes 94° and 95° 35′ west.

Main topographical features. In the details of topographical outline, the map will speak best for itself, but there are certain broad features which it may be well to notice. In shape, its apparently incomprehensible irregularity of outline is seen to conform to a certain systemmatic constriction or pinching off of the lake into different parts, by opposing peninsulas and belts

Constrictions. of large islands. The most prominent of this series of constrictions is that which divides the lake about its middle by means of the Grande Presqu'île and the island at its western extremity, stretching from Turtle Portage on the east to the mouths of the North-west Angle Inlet on the west. This great dividing mass of land appears to be the flat truncated remains of an immense anticlinal dome, the nature of which is described in another portion of this report. The portion of the lake to the north of Grand Presqu'île is again medially constricted, the space between the Eastern Peninsula on one side of the lake, and the Western Peninsula at Crow Rock on the other, being only seven and a half miles in width. This space is almost completely blocked by a belt of four large islands, trending east-and-west, in a curve concave to the south, with very narrow intervening channels. This also is due to a

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* Neither of these falls had as yet received a name, and both are usually referred to as the "Falls," so that considerable confusion exists as to which is meant. Rat Portage and the Lake of the Woods are becoming a summer resort of some importance, and it seems not inappropriate that the names of the natural features should be in keeping with the picturesque and romantic character which makes them so attractive. It is for this reason that I propose the somewhat fanciful names which appear in this text, trusting that they will be acceptable to my friends, the people of Rat Portage.

comparatively well defined anticlinal structure in the strata, in the denuded and worn hollows of which, the lake lies. The repetition of this process of subdivision is seen in the northern of the two bodies of water thus formed, in Pipe-stone Point, and a similar belt of islands comprising Hay, Middle and Scotty Islands, stretching from the east side of the lake to within a mile and a-half of the peninsula—an island at high water—on the west side, terminating in Point Aylmer. This also presents the characters of an anticlinal ridge. The same thing is repeated in the belt of islands between the Devil's Gap and Dispute Point, although the relations of topographical contour to geological condition is not so apparent.

Thus viewing the lake in its general aspects, there is seen to be a four-fold repetition of these dividing ridges or belts of land, corresponding to as many great folds in the original strata of the region, which, most largely developed to the south in the Grande Presqu'île, have left, as their denuded and truncated remains, these ridges, diminishing regularly towards the north, and cutting off sections of the lake successively smaller. **Four dividing ridges.**

To the south of the Grande Presqu'île, Pork Point, on the east side of the lake, and Driftwood Point on the west, with Bigsby, Big, Confield and other islands between, seem to constitute another belt, similar in character to those described to the north, and may be regarded as part of the same system of anticlinal, water-dividing ridges, although not embraced within the limits of the accompanying map.

Two important portions of the Lake of the Woods yet remain to be noticed. These are White-fish Bay to the east and Ptarmigan Bay to the North-west of the main body of the lake. The former of these is a large body of water, closely packed with islands and almost entirely cut off from the rest of the lake by the Grande Presqu'île. The only connecting channel is the narrow passage, less than a quarter of a mile wide, situated about six miles south-east of Yellow Girl Point. With the exception of its extreme north and south ends, it lies entirely in Laurentian gneisses. It occupies the hollows of the eastern flanks of the anticlinal dome of the Grande Presqu'île, and, as a glance at the map will shew, conforms closely in the general trend of its shores, with the curvilinear disposition of the strata. **White-fish Bay.**

Ptarmigan Bay is also pinched off from the main body of the lake and is connected with it by an almost equally narrow passage, formed by the approach of the extremities of the Western and Southern peninsulas. Zig-zag Point and Cork-screw Island serve to separate Ptarmigan Bay proper, from a northern portion called Clear-water Bay. **Ptarmigan Bay.**

Enclosed within the limits of the accompanying sheet is Shoal Lake, an extensive body of water, on a slightly higher level than the Lake of

the Woods, and separated from it by the Western Peninsula. It drains directly into Ptarmigan Bay, without the intervention of a river, by Ash Rapids, the name given to two small *chutes*, half a mile apart, with a little lake between. The difference of level between the two lakes varies with the abundance of water in different seasons. When the water is high, the lower rapid becomes obliterated, and it is possible to paddle over what at low water is a distinct fall of several feet. The level of Shoal Lake is much more constant than that of the Lake of the Woods, which has a rise and fall through a range of ten feet.

Shoal Lake. Shoal Lake, though not resembling the Lake of the Woods in shape, has this feature in common with it, that while the northern end of the lake is thickly studded with islands, the southern portion presents an open 'traverse,' comparatively free from them, and also, that whereas the shores of the north are bold and rocky, towards the opposite end of the lake, they are low-lying, and at the extreme south quite sandy, with almost no rock exposures. It is a triangular-shaped lake, with apex to the south, and a long, irregular, island-fringed east-and-west-trending shore for base to the north. Its greatest north-and-south extent is thirteen and a-half miles, and its greatest breadth seventeen miles.

Outline dependent on geological features. From the foregoing remarks, it will have been gathered that in the general features, the shape of the Lake of the Woods is dependent upon geological conditions. If we prosecute still further the investigation of this relationship, we shall find a surprisingly intimate connection, even in the details of the distribution of land and water. The dependence of the physical features of the earth's surface upon geological conditions becomes more or less apparent in all regions, when carefully studied, but nowhere could a better illustration of so interesting a truth be found than on the Lake of the Woods. The conditions which obtain in the rocks of the region, and which have had the most active influence in determining the aspect of its geographical features, are those of cleavage, relative hardness and mineral composition, and strike and dip. The strike and dip of the strata control more particularly the direction in which the forces of erosion operate, while cleavage, relative hardness and composition control rather the measure of rapidity with which these forces may act in the directions determined. These general conclusions, which may be regarded as an imperfect formulation of the law of erosion in these Archæan rocks, and which are based on a large number of observations in the field, may be illustrated by a few of the more striking instances that have been worked out.

Basin excavated in the schistose rocks. If we consider first the relations of that portion of the Lake of the Woods to the north of the North-west Angle and Falcon Island, including Shoal Lake as part of the same eroded basin, to the rock formations

of the region, we shall be struck with the fidelity with which the confines of the lake adhere to those which limit the distribution of the Keewatin rocks. The hard, massive, granitoid gneisses of the Laurentian seem to have constituted a firmer and more resistant girdle to the area of softer, schistose rocks of the Keewatin within which a more rapid erosion has worn out the irregular-looking basin which contains the waters of the present lake. It is a remarkable fact, however, that, although the outlines of the basin of the lake are evidently determined by the *locus* of the contact of the Laurentian gneiss and Keewatin schists, the gneiss itself rarely constitutes the rock of the shore-line, but is generally faced, so to speak, with the schistose rocks, as if the backing of gneiss lent sufficient stability to the adjoining schists to resist the erosion that has eaten more deeply into them in the central portions of their area.

Gneisses support the softer rocks.

The only places where the gneiss appears at the edge of the water of the portion of the lake-basin under consideration, are on the west side of Shoal Lake, where the shore-line crosses the strike of the rocks, instead of running parallel to it, as is usually the case; on the south-east side of Shoal Lake, where the gneiss seems to come to the surface in the axis of an anticlinal fold; in Clear-water Bay, where there is an unusual break in the continuity of the strike of the rocks; and at the extreme end of Big-stone Bay.

The larger massses of intrusive granite exhibit apparently the same tendency to remain encased in a margin or border of the schists through which they have been protruded, and although these massive granites seem to be more readily susceptible of erosion than the laminated gneisses, they still appear to occupy the central or nuclear portions of the masses of land in which the are found. Thus the Canoe Lake granitic mass occupies the central portion of the large peninsula which separates Shoal Lake from Ptarmigan Bay, and is almost entirely surrounded by schistose, hornblende-rocks, diorites and diabases, which form the shores of the lake. The Yellow Girl granitic mass occupies the central portion of the Eastern peninsula and is similarly surrounded by schists, the strike of which, bending around the central intrusion, has given direction to the three sides of the peninsula. The granitic masses of Portage and Carl Bays, lie in about the centre of the Western Peninsula, although here the shore-line is deeply and irregularly indented into the heart of the granite areas on both sides.

Resistence of various rocks to erosion.

The idea that the superior resistence to erosion exhibited by the rocks which lie between the shore-line and the gneiss which surrounds the lake basin, as well as the more prominent granitic areas, is in some way due to the proximity of these rocks to the gneiss or granite, is the one that first naturally suggests itself. This, in a measure, seems to be

true, although it is not the full explanation of the facts. The hornblende-rocks in contact both with the granites and granitoid gneisses, seem to be harder, tougher, blacker in color, and of a more freshly crystalline aspect than those at a distance from such contact. And it is altogether probable that these schistose hornblende-rocks have derived this extra hardness and toughness from the adjoining granites and gneisses, particularly since, as I shall endeavor to show elsewhere, the gneiss behaves, in its relations to the rocks with which it is in contact, exactly as intrusive granites do. But while these facts are to be considered in an estimation of the causes that have influenced the measure of erosion, it is to the mineralogical character of the rocks and their consequent relative hardness, independent of superinduced effects, that we must look for the more comprehensive explanation of the features of erosion. The difference in composition and hardness of the rocks in different portions of the lake is quite marked. The soft, fissile hydromica and diloritic schists are at one end of the scale, and the hard, black, schistose, hornblende-rocks, and massive basic rocks at the other, with mica-schists and agglomerates intermediate. The hornblende-schists, occupying for the most part the borders of the Keewatin area, and of the lake-basin, have been less liable to disintegration, *per se*, altogether apart from the fact of the contact with the gneiss or granite, while the hydromica-, chlorite-, agglomerate- and mica-schists, occupying more extensively the central portions of the area, have more easily yielded to these forces decomposition and disintegration which have worn out the hollows in which the lake lies.

Strike in relation to shore-lines.

The influence of strike in determining the direction of shore-lines, is however, the most notable feature in the relationship of geography to geology. Nearly all the rocks of the region are tilted at high angles, and the shore-lines of all parts of the lake, with few exceptions, tend to coincide with the trend of the strike. If the rocks dip away from the water inland, so that the cliffs have an overhanging aspect, the coarse disintegration of the rock proceeds more rapidly than when the dip is toward the water, and presenting a sloped face, which is much stabler as a barrier against the disintegration ting influence of wave and weather. But in either case, the line which in general limits the extent of the erosion and gives shape to the shore, is the line of strike. A few instances, illustrative of the close dependence of the direction of shores upon the trend of the rocks are given as follows:—

List of Coincidences of Shores with the Strike of the Rocks.

General axis of Pipe-stone Point	S 81° E.
Average strike of schists (25 observations)	S 80° 48′ E.
General bearing of shore from Rat Portage to west of Keewatin.	N. 74° E.
Average strike of schists (7 observations)	N. 74° 18′ E.
General axis of Indian Bay	N. 51° E.
Average strike of schists (9 observations)	N. 49° 36′ E.
General bearing of shore, Point Aylmer to Ptarmigan Bay	N. 65° E.
Average strike of schists (17 observations)	N. 61° 6′ E.
General axis of Heenan Point and Needle Point	N. 22° E.
Average strike of schists (4 observations)	N. 21° E.
General bearing of north shore of Grande Presqu'île	N. 83° E.
Average strike of schists (16 observations)	N. 71° 48′ E.
General axis of Clear-water Bay	N. 86° E.
Average strike of schists (17 observations)	N. 81° E.
General axis of Ptarmigan Bay	N. 85° E.
Average strike of schists (28 obsverations)	N. 82° 12′ E.
General axis of Indian Bay, Shoal Lake	N. 72° E.
Average strike of schists (10 observations)	N. 75° E.

But the most remarkable instance of the dependence of shore outline upon the strike of the strata is that afforded by the Eastern Peninsula. This is a large, thick, three-sided mass of land, about nine miles long, projecting into the lake from the east side. Its central portion is occupied by a large mass of intrusive granite, which, breaking through the schists, has upheaved them and caused them to strike around the central mass in directions which seem to be the three sides of a rhomboid, the area of upheaval being coincident with the short diagonal of the rhomboid. In close correspondence with these trends in the strike of the strata are the shore-lines which define the shape of the peninsula. This will be seen, as before, by taking, as nearly can be judged, the general bearings of the shores and comparing them with average of the observed strike of the rocks exposed along them. Shore-lines of Eastern Peninsula.

General bearing of north shore of Eastern Peninsula	S. 83° E.
Average strike of schists (12 observations)	S. 82° 30′ E.
General bearing of S. W. shore of Eastern Peninsula	N. 66° W.
Average strike of schists (9 observations)	N. 75° W.
General bearing of south shore of Eastern Peninsula	N. 83° E.
Average strike of schists (5 observations)	N. 81° E.

There are but a few of the many instances that might be adduced. Nearly all the minor points and bays of the lake which occur within the Keewatin area, have their shape determined more or less closely by the strike of the rocks, modified, of course, materially when there occurs a change in the character of the rocks, as, for instance, when a schist gives place to a hard massive diorite or diabase.

Denudation.

Denuding agencies.

The forces of erosion, however, concerned in the sculpture of this lake-basin, have by no means been simply those of ordinary shore disintegration. The lake, as such, is probably, of post-glacial origin, and the disintegration that has been affected since the basin it now occupies became flooded, is a very small fraction of the immense denudation that took place prior to, and by means of, the glaciers. In fact, the denudation of the region may, for convenience, be briefly considered nnder these three heads, which are in order, both of time and relative importance, viz :—

1. The denudation which preceded the glacial epoch.
2. The denudation affected by the action of glaciers.
3. The disintegration of the rocks since the glacial epoch.

Pre-glacial Denudation.

Rock decay and removal.

The first of these comprised two sets of forces, (1) those f rock decay and comminution, both chemical and mechanical, but chiefly chemical, and (2) those engaged in the removal of the debris to lower levels, also both chemical and mechanical, but chiefly mechanical. As regards the latter, the forces of removal, the conditions which obtain throughout the region point to their having been very moderate in intensity and gradual in their operation. The whole region, although extremely hummocky or mammilated in its surface aspects, presents extraordinarily little variation in level. There are no great valleys or high hills. The whole country is practically a plateau of very moderate elevation above the sea for so inland a region. In alluvial regions a comparatively rapid removal of surface material may take place without sharp contrasts of level existing, but in regions such as western Algoma*, where the surface is, and probably has been for ages, rocky

* The name of an electoral district, embracing the western part of Ontario as far as the boundary of the Province of Manitoba, which may be conveniently used in referring to the country west of Lake Superior, within the Province of Ontario.

denudation is, in the nature of things, much slower and more moderate in its action when that region is flat, than when it is mountainous. There is no evidence that the Archæan rocks of this district have at any period of their history been thrown into what may be truly called mountains, in contrast to the general level of the crust at the time when all these rocks were folded. The mountains of the globe, with which we are familar, appear to be, for the most part, simply linearly arranged areas of abnormally thick strata, deeply carved by a process of excessively active denudation. The plication of the earth's crust in itself has never been demonstrated to produce mountains independent of conditions of excessive accumulation of strata. The Archæan rocks of western Algoma are intensely plicated, yet that fact does not warrant us in assigning a once mountainous character to the region. Rapid denudation in rocky regions is characterized by high altitudes and deep gorges, partly as a cause and partly as an effect of such denudation. The wearing down of mountain ridges to the generally uniform level of the Algoma plateau, would certainly have been attended by the erosion of immense valleys and gorges, corresponding in their dimensions to the altitude of the mountains for whose debris they would have constituted the channels of removal. There are no great valleys or ravines cutting out this plateau. It may have been a plateau since Archæan times, probably of much more uneven surface than it now presents, but always of a generally uniform level. The southern flanks of this great Archæan plateau, in its extension east and west from the particular portion under consideration, appear to have been in much the same flat condition, as at present when the Animikie and Copper-bearing rocks of Lake Superior, and the Cambro-Silurian rocks of Manitoba and eastern Ontario, were laid upon them in the earlier geological periods.

District probably never a mountainous one.

But denudation implies rather the stripping off or removal of the loose material that has been reduced to a state of comminution by the agency of rock decay and disintegration. Of course, the less active the agencies of removal, the less often is fresh material exposed at the surface to the attacks of eroding forces. Rock decay, however, is not altogether confined to the surface, although disintegration is. Dr. T. Sterry Hunt has pointed out the probability that all the rocks of our Archæan regions were, in times prior to the glacial epoch, decomposed and soft to a considerable depth. In the same connection he advances the view, that a large proportion of our glacial erratics are simply the undecomposed nodules that have been left unaffected by this decomposition. Some facts that I have been able to observe on the Lake of the Woods, which lend support to these views, may be worth recording. The granitoid gneiss is not infrequently found to be remarkably decomposed or 'rotten' in areas of limited extent which appear to

Process of rock decay.

Instances. have an approximately vertical attitude. In these areas, the same rock which a few yards away seems quite hard and fresh, is so soft and decomposed that it may be broken off by the hand, and crumbled between the fingers like a piece of loaf sugar. Two localities where this is most characteristically seen are on the west side of Falcon Island and on the west shore of the Grande Presqu'île. At both places, the shore presents a cliff of gneiss in which a vertical belt of rotten, friable rock, about a dozen yards or so in width, runs through the hard gneiss. The gneiss is coarse-textured with large porphyritic crystals of orthoclase and in the decomposed portion presents a rusty yellow appearance. The weakness of the rock appears to lie in the almost total lack of coherence between the quartz and mica. There is a considerable proportion of pyrites in the gneiss, but not more than is often found in such rocks when quite fresh. It is easy to conceive this rotten friable character of the rock to have once been much more prevalent, and that these downward-running belts of incoherent material may be but a survival or rudimentary stage of what was an almost universal condition of the surface of the Archæan rocks, before the glaciers came and scraped them clear to the hard and comparatively firm portions, upon which we now find engraved the glacial grooves and striæ.

Hard kernels in gneissic rocks. On a small island south of Flag Island Point, the granitoid gneiss has the appearance of having enclosed within it rounded boulders of granite such as are shown in the annexed diagram. (Fig. 1.)

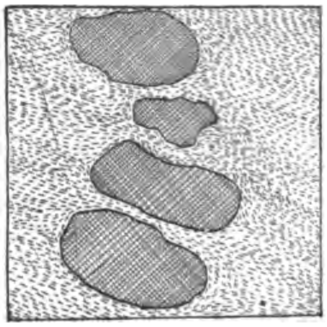


FIG. 1.—HARD KERNELS IN GRANITOID GNEISS.

The gneiss of the island, though quite granitoid, has still a perceptible lamination, the strike of which may be observed with little difficulty on a large surface although hard to discern in a hand specimen. The gneiss is much decomposed and has a bleached or yellow aspect, but is not noticeably soft or friable. The apparently included boulders were found on inspection, though seemingly different, to be the same

as the rest of the rock of the island, so far as composition and texture are concerned They were not, however, bleached, but had a fresh purplish-red hue, and were evidently much harder than the surrounding rock, from the fact that they weather out with a well rounded shape above the encircling, saucer-like hollows that have been worn out around them. The laminated structure is almost totally absent in these pseudo-boulders, as if that lamination were in some way a function of the decomposition of the rock. The lamination of the gneiss, exhibits a tendency to curve around these harder, ball-like portions. The line of demarcation between the gneiss and these boulders, which are doubtless undecayed nuclei of the same material, is rather a sharp one, but is not without evidences of transition. Around one of them there is a border half an inch wide, of a brownish color, intermediate between the purplish-red of the nucleus and the bleached yellow of the enclosing rock, which seems to mark the mergence from one to the other; and in the others, the line is not sharper than that found in many of the granitic rocks of the region dividing the two or three inches of bleached kaolinized surface rock from the fresh, bright-colored portions that have not been as yet perceptibly changed. These nuclei of hard rock in the midst of the gneiss are very suggestive of the origin of many of the rounded boulders.

Glacial Denudation.

Glacial denudation not profound.

The evidences of glacial action, so abundant in all parts of the lake, will be dealt with in another part of this report, but a few words may be said here about its erosive effect. The Lake of the Woods and surrounding country may be considered essentially as a partially flooded area of *roches moutonnées*. The whole country has been scraped bare, polished and grooved. But this scraping and polishing process seems to have done little more than expose the natural surface of comparatively undecomposed rock, upon which had previously rested, *in situ*, the upper decomposed soft portion. The curving of well defined grooves around sharp angles of solid rock, their passage over rock-surfaces presenting marked unevenness, due to jointing, and their bending under overhanging cliffs of massive rock, seem to leave little room for the belief that glacier ice had the power of rending solid rocks and carrying them off in fragments. Its action was confined to the removal, first of the loose earthy material, the result of rock decay, then by a process of attrition or grinding of the less decomposed but still soft lower portions, till the level of the present *roches moutonnées* were reached, presenting a surface sufficiently hard to be

Causes producing *roches moutonnées.*

grooved and polished. Thus the *roches moutonnées*, although they may be said to be the immediate result of glacial action, have their more remote and truer cause in the process of rock decay, the present mammilated surface of the country being simply the limit to which decay had so affected the rocks as to render them removable by glacier ice. The fact that the phenomenon of *roches moutonnées* is confined to regions of crystalline or Archæan rocks and not displayed in ordinary unaltered sedimentary rocks, even though profoundly glaciated, is strong presumptive evidence in support of the phenomenon being regarded as dependent, rather upon the character of the rock and the forces at work in it, than the result of any incomprehensible peculiarity in the action of the ice. The Cambro-Silurian and later sedimentary rocks in Manitoba and eastern Ontario are invariably polished and grooved in horizontal or nearly horizontal planes, with abrupt faces or escarpments at changes of level, never rounded into domes or *roches moutonnées.*

Post-glacial Disintegration.

In this partially flooded area of *roches moutonnées* which we may consider as constituting the basin of the Lake of the Woods, there have been going on in post-glacial times very active processes of erosion, but owing to the brief geological time that they have been in operation, their effects have had an insignificant influence upon the general features of the country in comparison with that which went before. The chief of these is the shore erosion acting along lines defined by geological structure, the principle of which has been already spoken of. The rock debris along nearly all the shores of the lake basin is of two kinds, that which has been dropped as erraties in their passage, and that derived from the immediately adjoining rocks, which has been detached since the lake assumed its present shape. There is a considerable talus of angular blocks at the base of all precipitous cliffs, due to the combined action of frost and gravity; and not infrequently a wall of rock is seen to be shattered and torn as if by a violent explosion. The cause of these disruptions is said by the Indians to have been lightning. Forest fires have been very effective agents in bringing about the coarse disruptions of the rocks of the region. If a camp fire be built on a bare surface, the rock beneath it will have been shattered and peeled off from a depth of an eighth of an inch to an inch or more by the time the kettle has come to the boil. When a forest fire sweeps a country, this same cracking and peeling off of the rock, due to the excessive expansion of the surface, takes place on an

Shore erosion.

extensive scale. As a rule, there is little or no soil to protect the rocks, the trees growing in fissures or in small patches of sand; and the mosses which conceal them burn for days after the half-charred trees have ceased to smoke. The slabs or tablet-like fragments of rock thus separated are found strewn over the sterile country of the region. The slabs are, as a rule, slightly curved and concentric with the rounded, generally glaciated, surface from which they are detached. Action of fires.

This same tendency of the rocks to peel off in concentric layers is exhibited in situations where fires could not have been the cause. The phenomenon is seen chiefly in granitic and gneissic rocks and occasionally in massive basic rockss. The rocks are nearly always rounded in shape and are seen to be peeling off at the surface in curvilinear sheets. Sometimes it is possible to detach these sheets of rock with the fingers, but in the majority of cases they are firmly adherent to the main mass of the rock. Often two or three such layers or sheets are seen one above the other, the outermost extensively removed and the inner least so, forming a miniature series of steps. The thickness of the layers is generally about a quarter of an inch. The tendency of the rocks to become disentegrated in the fashion indicated, though not attributable to the agency of fire, since it can be seen below the high-water mark, is doubtless due to the operation of the same internal forces less actively excited, viz., the unequal expansion of the rock at different depths from the surface due to variations in temperature. Concentric weathering.

In a region where soil is so scanty, vegetation plays an important part in the coarse disintegration of the rocks. The roots of trees are everywhere prying up blocks of the rock into the joints and fissures of which they have penetrated, and it is no uncommon thing to find angular masses, several tons in weight, lifted one or two feet out of their natural resting place, or even dislodged entirely by the slow growth and expansive force of the roots. The lower forms of plant life are also active agents in dislodging and bringing to lower levels the loose blocks formed by jointing and cleavage. The growth of mosses and grasses in the cracks of rocks is constantly attended by the movement or pushing out of the angular blocks, wherever such movement is possible. This movement, however, is doubtless partially due to the congelation of the moisture that would naturally accumulate in such a plant-filled fissure, as well as to the expansive force of the vegetation itself. Action of vegetation.

Animals, too, are not without their influence in the dislodgment of loose blocks from higher to lower levels. One has only to walk through those portions of the region where bears are common to observe the large numbers of rock fragments that these powerful animals have Other denuding agencies.

pulled from their places or rolled over in their search for ants and grubs. These are the more manifest forms of rock disintegration at play. Other subtler forces are however at work, such as those of surface solution and mechanical wear, but their effect has been, as is amply shown by the distinctness of the grooves and striæ, so extremely slight, that they do not require to be noticed here, beyond observing that there is quite a perceptible difference in the measure of their action upon those rocks, exposed on the top of the bare domes and ridges to the full influence of aërial agencies, from that upon the rocks near the water-level or below the high-water mark. The striæ and grooves below high-water mark are always much fresher and more distinct than those on bare surfaces higher up. The present aspect of the glaciated rock surfaces along the water's edge bears much the same relation to that of the lichen-covered rocks away from the water, as a polished and engraved surface of steel might do to that of a similarly engraved but rusted piece of iron. The waters of the lake have evidently had a protecting influence upon the rock surfaces along their shores, keeping them from the organic acids of vegetation and the carbonic acid of the atmosphere, which have eaten into the surface elsewhere, and rendered the grooves and striæ faint and sometimes scarcely perceptible.

Weathering of glaciated surfaces.

General Character of the Rocks of the Region.

Study of these rocks as yet incomplete.

The rocks here designated as the Keewatin series are of much interest, whether regarded from a purely petrological or from a geognostical point of view. Not only would a thorough study of these ancient altered schists and their associated massive rocks be of the greatest value to lithological science, as such, but the knowledge derived from such a study is almost an essential preliminary of any investigation as to the origin and natural history of the series. Such a study, it is to be regretted, these rocks have not received, at least with that scientific thoroughness which their full comprehension demands, excepting in so far as I have been aided by the kindness of Dr. G. H. Williams, of John Hopkins' University, who has had a collection of the more interesting rocks lithologically examined by Mr. W. S. Bayley, under his own supervision. For rocks not so examined I can only give the general microscopical character, upon which, supplemented by the results of Mr. Bayley's microscopic examinations, the lithographical mapping of the area is based.

The rocks of the region may, for convenience, be considered under the

following classification, in which regard is paid as much to their geological relations as to their lithological character. Classification of rocks.

Gneiss.
Granite.
Felsite, Micro-granite, Porphyry.

Schistose hornblende-rocks.
Diabases aud Diorites.
Serpentines.

Coarse Clastic rocks and Agglomerates.

Mica-schists, Micaceous slate, Quartzites, Clay-slates.
Felsitic schists.
Soft Hydromica-schists and chloritic schists (with other soft silicated magnesian schists.)
Carbonaceous schists.

Limestones.

In the following brief descriptive summary of the rocks, Mr. Bayley's report on the microscopic sections he examined for me will be largely drawn upon, and, indeed, almost entirely incorporated with my own notes, from which, howover, it will be readily distinguished by being placed within quotation marks.

Gneissic Rocks and Granites.

The granitoid gneisses, which underlie the Keewatin rocks, may be said to be characterized by a fairly well-marked and persistent porphyroid structure. The feldspar is the most abundant constituent, and most prominently developed crystallographically. Almost everywhere along the line of contact to the south of the Keewatin area, the gneisses are of very coarse textures, and this is true of the gneiss for considerable distances across the strike of the foliation, in some places the orthoclase crystals attaining a diameter of an inch or more, with a distinct, flowed structure of the other constituents of the gneiss around them, approaching typical augen-gneiss in appearance. General characters.

Another characteristic feature of the gneisses surrounding the area is their passage into granites devoid of foliation. The rock in the vicinity of Pine Portage mine, to the east of the contact with the schists, in which the shaft is sunk, is a reddish, to mottled flesh-tint and green, coarse-textured rock, of eminently granitic aspect. All the constituents, orthoclase, mica and quartz, are well developed and coarsely crystalline, and there is no trace of gneissic foliation. The rock is described as follows by Mr. Bayley.—

Gneiss near Pine Portage Mine.

Section No. 11. "Very much like section No. 15. It may, however, be considered as a porphyritic granite. Though there is nothing in the slide examined to show that the quartz and felspar grains of different sizes are not of the same generation, it seems better to class this among porphyritic granites, since the ground-mass, though not fine-grained, appears as micro-granitic when compared with the larger crystals. The quartz is water-clear, and contains very small fluid inclusions with movable bubbles, and fine, black needles, probably of rutile. The orthoclase is charged with kaolin. The plagioclase, as in No. 15, is fresher than the orthoclase, and possesses the same twinned structure. It has in it inclusions of epidote and the same black needles noted in the quartz. The biotite is slightly darker than in No. 15, and is accompanied by titanic iron, leucoxene and green epidote. In same cases it is decomposed, giving rise to a slightly pleochroic, dark-green, aggregate of small scales. In other respects it is very much like No. 15."

This rock, so characteristically granitic in its nature, may be traced eastward over a comparatively bare country, and be seen to assume gradually, by transitions scarcely perceptible, a gneissic arrangement of the crystals, till at last, on the shores of Long Lake, it presents a quite distinctly gneissic foliation, and, as will be shewn elsewhere, presents more and more the character of an intrusive breccia in proportion as the gneissic foliation becomes more distinctly developed toward the south east.

Gneiss of Dog-tooth Lake, etc.

The gneiss of Dog-tooth Lake, South Arm, is granitoid, but still distinctly foliated. The feldspar predominates in large crystals, giving it a porphyroid aspect. The quartz is in clear irregular grains and masses, and the black mica is in small, thin, uniformly arranged flakes, with which are associated a yellowish epidote-like mineral. The rock is reddish to salmon-color and apparently passes into varieties of the same rock which are quite granitic and devoid of foliated structure.

Near the head of the Rushing River, on the same lake, the gneiss is a gray, coarse-textured, faintly foliated rock, composed of nearly equal proportions of whitish felspar and clear quartz, with somewhat sparsely disseminated black mica in thick tablets and thin flakes.

Between Blind-fold Lake and the junction of gneiss and schist on Hollow Lake, the rock is a coarse, gray, well-foliated gneiss, composed chiefly of white felspar and black mica, but with a considerable proportion of quartz. Mixed with the orthoclase are a number of plagioclase crystals distinctly striated. This gneiss forms the matrix of a breccia in which the included fragments are blocks of hornblende-schists derived from the Keewatin rocks with which the gneiss is in contact half a mile to the south.

Of the gneisses to the south of the belt, that of Astron Bay may be taken as a fairly representative type. Near the junction with the schists it is of a more or less granitoid aspect, with thin, sharply defined micaceous foliæ, not continuous, but uniform in direction. It is of coarse texture and very quartzose. The felspar is apparently all orthoclase, varying in color from white to flesh tinted. Half a mile to the south of the contact, the gneiss is more coarsely textured and less evenly foliated. The proportion of quartz is less and there is present a quantity of plagioclase in finely striated crystals. The color of the rock is a pepper-and-salt gray. Gneiss of Astron Bay.

The gneiss in contact with the hornblende-schist on the south side of Birch Island is microscopically a grayish, medium-textured, foliated rock, composed of whitish felspar and quartz, with sharp, thin, leaf-like foliæ of black mica uniformly arranged, and with needles of a black hornblendic mineral. Microscopically, Mr. Bayley reports on it as follows :—

"Section No. 4 is a typical gneiss. It consists of a tolerably fine-grained ground-mass of quartz and orthoclase, containing shreds and plates of biotite arranged parallel to the lines of schistosity. Considerable green hornblende mixed with a little biotite and hæmatite are massed together, forming aggregates whose longer diagonals are parallel to the schist plane. Besides these, well developed individual crystals of hornblende also occur. In this ground-mass large crystals of feldspar are numerous. A little orthoclase with zonal structure is twinnod according to the Carlsbad law. Beautiful plagioclase in irregular broken pieces shows evidences of pressure twinning. The twinning lamellæ are bent and in a few cases the crystals are broken and faulted as if they had been subjected to considerable pressure. They all possess a well marked zonal structure and are twinned according to both laws. The larger pieces are surrounded with little mica plates. The orthoclase is just a little cloudy with decomposition products. Apatite, epidote, titanic iron and leucoxene are the secondary minerals." Microscopical characters.

The gneiss on the west side of Shoal Lake, near Snow-shoe Bay is a reddish rock composed of orthoclase and black mica, with quartz as a less prominent constituent. The foliation is rough and irregular, but distinctly gneissic. Gneiss of Shoal Lake.

The gneiss of Quarry Island, a boss, apparently intrusive, projecting through the firm hornblende-schist of the north-eastern portion of the lake is an exceedingly coarse, roughly foliated porphyroid rock, in which the feldspar is present in crystals often half an inch or more in diameter, very cleavable and of a white color with a faint lilac tint. Black mica is plentiful and is gneissically foliated, not in flakes or tablets,

but in irregular aggregations of fine scales. Quartz is not abundant, but is noticeably of a milky blue color. A prominent accessory mineral is molybdenite in fine scales, which, however, appears to be rather associated with fine quartz veinules than to exist as a constituent of the rock. The rock though quite distinctly foliated in some portions of the mass is in others almost quite granitic in its texture.

Gneissic foliation in granite dyke.

A good instance of the gneissic foliation assumed by granitic intrusion is that afforded by a dyke, cutting hornblende-schists transversely on a small island two and a-half miles south-west of Yellow Girl Point. The dyke is apparently an offshoot from the larger granitic mass which occupies the south half of Beacon Island, which is itself for the most part granitic in texture but foliated in places, particularly near its contact with the schists. The dyke is about fifteen feet wide and crosses the small island from south to north with a curved direction as represented in the accompanying diagram.

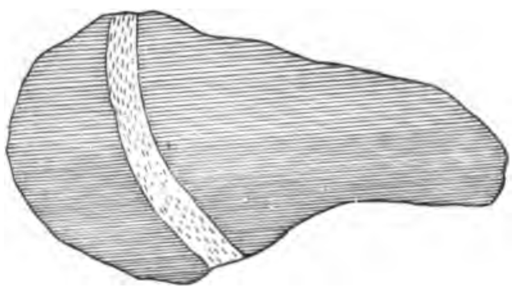


FIG. 2.—FOLIATED GRANITE DYKE, CUTTING SCHISTS.

The rock of the dyke is foliated in a direction parallel to its walls, but this foliation is much more prominently developed towards the sides of the dyke than in its central portions. The rock is of a pinkish-grey color and the foliation is somewhat wavy. Its lithological characters are thus described :—

Microscopic characters.

"Section No. 45. Gneiss very similar to No. 4. It contains less mica and hornblende and more feldspar, both in porphyritic crystals and in the ground-mass. The feldspar, both orthoclase and plagioclase, is much more decomposed, and consequently the whole slide is filled with sheets of muscovite. The plagioclase has the true microcline structure. A few round grains of clear quartz and quite a quantity of calcite also occur, the calcite filling in between the other constituents."

The Yellow Girl granite mass may be taken as the type of the intrusive granites of the region. As will be gathered from the map,

this granite occupies the central portion of the Eastern Peninsula, and constitutes the nucleus of a great area of upheaval, around which the strata trend, tilted at high angles. Microscopically, the rock consists of a granular ground-mass of reddish to flesh-tinted felspar, quartz and mica, in which are imbedded large porphyroid crystals of orthoclase and occasional smaller crystals of striated plagioclase. Its microscopic characters are given as follows :—

Yellow Girl granite.

Section No. 15.—"This rock is a typical granite. Under the microscope it is seen to be composed of irregular grains of limpid quartz, orthoclase, plagioclase and a little pleochroic green biotite, which has been slightly bleached around the edges.

Microscopic characters.

"The quartz contains numerous liquid inclusions with little dancing bubbles. These inclusions are generally arranged in lines and have the form of negative quartz crystals. In addition to these, the quartz contains beautiful little crystals of sphene (∞ P and O P), and a few octahedra of magnetite. The orthoclase is almost all changed into kaolin. It contains also little hexagonal plates of hæmatite. The plagioclase is fresher and shews a beautiful zonal structure, as does also the orthoclase in some cases. In one instance, six distinct bands were very clearly discernible on a slightly decomposed orthoclase crystal. The plagioclase is twinned according to both the albite and pericline laws, and in many instances possesses the appearance of having been bent. This is particularly well seen in those long crystals which have very fine twinning lamellæ.

"The biotite is slightly decomposed, and is accompanied around its edges by sphene and slightly pleochroic grass-green epidote in very ragged grains. Apatite crystals are rare. Small particles of magnetite are scattered through the interstices between the other constituents, especially around the mica, and these, on oxidation, change into the sesquioxide, which stains the rims of the quartz and feldspar red."

Another specimen of granite, of which a section was examined, is that of a dyke running parallel with the schists on a small island south of the extreme west point of Wind-fall Island. It is a light greenish-gray, rather finely granular rock, resembling rather a felsite than a granite in its general aspect. It is thus described.—

Granite near Wind-fall Island.

"Section No. 6 is a true granite (biotite-muscovite granite). This slide shews that the rock is composed essentially of small plates of pinkish-brown biotite, slightly pleochroic, small plates of green hornblende, round grains of quartz and feldspar and considerable muscovite. The quartz is limpid, with irregular gas- and oval fluid-inclusions, rarely apatite crystals and frequently slender, black needles. The feldspars are like those in Nos. 15 & 11 the plagioclase, however, being much clearer, and the orthoclase containing a great many inclusions of

various kinds. The muscovite is in tolerably large plates and includes small crystals of the other constituents of the rock. Among the accessory minerals are plates of green hornblende, small grains and crystals of magnetite, little plates of hæmatite and apatite needles. Some of these have been broken and bent about, the broken pieces making an angle of about 135° with each other."

Felsites.

Closely connected with the granites of the Keewatin area, is a series of intrusive felsites. These, as will be noted farther on, break through the schists in the vicinity of granitic masses, with which they are probably genetically connected, although they have cooled more rapidly and under other different conditions. They occur in dykes and irregular masses which shew a tendency to arrangement more or less concentric with the confines of the main granitic mass. A good typical example of this felsite is that of which a section has been examined from an island in Shoal Lake, just to the west of the peninsula separating Bag Bay from the main body of the lake. The following are Mr. Bayley's notes on the section.—

Micro-felsite from Shoal Lake. "Section No. 42, is a micro-felsite. Under the microscope, in polarized light, it appears as a very fine-grained mosaic of quartz and feldspar, with here and there a somewhat larger grain of limpid quartz, or clear plagioclase, and frequently a little irregular patch of secondary calcite.

"Scattered through this ground-mass are plates of very light mica, surrounded by rims of decomposition-products, crystals of sphene and a very small amount of biotite. In the slide examined, there were only a very few shreds of green-brown mica, mixed with magnetite. The most interesting mineral in this rock is a blue tourmaline. It is strongly pleochroic and is grouped like a tuft of grass. It is most common around grains of pyrite, which have begun to decompose. The other products of this decomposition are hæmatite and an ochreous stain, which penetrates the general mass for some distance around each decomposing particle."

Felsite from Echo Bay. On the north side of Echo Bay another patch of felsite, of a purplish colour, occurs to the north of the Canoe Lake granitic mass, which is thus described:—

"Section No. 28 is very much like No. 17. The hornblende is darker in color. The plagioclase shews feebly the original twinned structure. The quartz contains liquid inclusions with bubbles.

"It differs from No. 17 in containing a great deal of calcite all through the ground-mass, in irregular patches between other constituents as well as in little colourless rhombohedrons. Perfectly developed brown

rhombohedrons also occur. They are probably dolomite or calcite. The massive calcite is often coloured with ferric oxide, when it takes on exactly the same appearance as is seen in these little rhombo hedrons. They are most frequent in the neighborhood of a vein of quartz-mosaic which runs through a portion of the section examined."

Feldspar-porphry, Quartz-porphry, Serpentine.

Between the two great granite masses of Portage Bay and Carl Bay, and separated from them by intervening belts of hornblende-schists, is a somewhat extensive area of a purplish-grey feldspar-porphyry. The rock is apparently a large intrusive mass, and is probably akin in origin to the regular granites in close proximity to it on either side. Its lithological characters are thus given.— Feldspar-porphyry.

"Section No. 44 is an altered felsite with porphyritic crystals of plagioclase. If eruptive, it might be classed with the micro-granites. A very fine-grained ground-mass, contains octahedrons of magnetite, small plates of brown biotite and considerable calcite. In this are imbedded larger, irregular grains of calcite, large pieces of plagioclase crystals with twinned structure, though cloudy with decomposition products, Carlsbad twins of orthoclase, with zonal structure, and aggregate of brown mica, bleached mica, (probably muscovite) magnetite and hæmatite."

An intrusive rock of another kind is that described by Mr. Bayley as:—

"Section No. 33. Quartz-porphyry. This rock consists of a micro-crystalline ground-mass of quartz and plagioclase, forming a mosaic of round clear grains. In this ground-mass are large crystals of plagioclase, twinned according to both the albite and pericline laws and consequently having the twinned lamellæ making an angle of 86° with each other. These large crystals have begun to undergo alteration into kaolin. Large grains of water-clear quartz contain inclusions of the ground-mass, mica, and now and then a crystal of light-yellow zircon. Besides these are the usual fluid inclusions with movable bubbles. Quartz-porphyry.

"This originally contained a green mica with rutile needles like that described by Dr. Williams from Tryberg. Very little of the original mica remains. Most of it has been changed, giving rise to a brown ochreous substance which has separated out and left a perfectly colorless mica. The rutile, being less liable to alteration, has been left in its original position and now appears as brown needles arranged along cleavage lines of the bleached mica, or cutting each other at an angle of about 60°. Other products of this decomposition are pyrite, titanic iron and leucoxene."

Association of rutile and biotite.

Another view of the association of the rutile needles with the mica is that given in a footnote to Mr. Bayley's report by Dr. Williams who remarks:—"The association of this mineral with the decomposed biotite is very interesting. In this case, however, it appears not to have been an original inclusion in this mineral, as Mr. Bayley thinks, but rather a result of altèration. Rutile in de composed mica has been very frequently observed by Zickel, Cross, Sandberger and others and owes its origin to the separation of the TiO_2 which so many biotites contain in their fresh state. This more rarely appears as anatase or sphene. (The latter mineral seems to have been formed in some other cases described as in Section 42, &c.) The only instance recorded of rutile in fresh biotite is that above mentioned. The other explanation is however here more probable."

Association of quartz-porphyry and serpentine.

The quartz-porphyry, whose lithological characters have been just detailed, occupies the greater portion of a small island, two and three-quarter miles south-west of Wiley Point, and is evidently associated with a mass of serpentine which occupies a small island beside the north, and the neighboring point on the main shore a little to the south-west. The serpentine on this point presents no definite relations to the other rocks, beyond the fact that it is in contact to the west with dark-green somewhat chloritic hornblende-schists, and that on the east, the point is tipped with a nob of hard crystalline dioritic rock. On another point of the shore, one and a-half miles to the north-east of this, occurs a second mass of serpentine, under conditions very similar to those just described. It is in contact to the west with green schists as before, and the extremity of the point occupied by the same dioritic rock, but with this difference, that between the diorite and the serpentine there is a dyke fifteen feet wide of the quartz-porphyry, evidently an offshoot from the main mass occupying the island off-shore a little to the south. The masses of serpentine on those two points and on the small island in immediate proximity to the quartz-porphyry are nearly in a line, and also in a line with the general strike of the rocks at this locality; but whether the serpentine is interbedded with the schists, or was originally intrusive, it is difficult to say from the evidence available in this particular case. The presence of the quartz-porphyry as an intrusion, associated with what appear to be dykes of diorite striking parallel to the dyke of quartz-porphyry, would seem to warrant us in regarding all these rocks—serpentine, diorite and quartz-porphyry—as different manifestations of outflows along a line of fissure, probably at widely separated intervals, and altered according to the well known tendency of these rocks, or rather of their original forms.

Other associations of serpentine.

Having proceeded so far with the description of this serpentine in connection with its association with the quartz-porphyry, it is desirable to give here its lithological characters rather than defer it to a more systematic place. In the same rock mass there are two varieties. One of these is a finely granular mottled purple and green, rather hard rock, while the other is a more coarsely granular, uniformly dull-green softer rock. Both of these are in places quite schistose, though for the most part massive. Little short segregations of chrysolite or picrolite with here and there a well-defined vein of ribanded chrysolite and white dolomite, run through the rock. There is a sufficiently large proportion of magnetite in it to create a marked deflection of the compass. The first of these two varieties is described by Mr. Bayley as follows.— Two varieties of serpentine.

"Section No. 32. In this rock the forms of the original olivine can be clearly seen. There is no trace, however, of this mineral left. It has been completely changed into fibrous serpentine. The spaces between the rounded grains of serpentinized material are filled with calcite, in which are scattered chromite, hydrated oxide of iron, and a cloudy, grey opaque substance in very fine dots." Microscopic characters.

The following note is descriptive of a section of the second variety.—

"Section No. 31 was probably originally a rock very much like Section No. 5. It has undergone alteration to such an extent that it is impossible to determine whether there was any olivine in the fresh rock or not. As it now occurs it is made up almost entirely of serpentine, with some remains of a fibrous mineral, with an extinction of 0°—2°, and quite a quantity of the ordinary iron minerals.

"The fibrous mineral is probably enstatite, and would, if it were fresh, give sharper extinctions. The extinctions are never interfered with by fibres of serpentine running through the length of the minerals."

Schistose Hornblende-rocks.

The general macroscopic characters of these rocks are best described by noting the different forms under which they appear. These are first, a very hard and tough, compact, fine-grained black rock, with scarcely any definite schistose structure perceptible in it. Secondly, they occur as rocks differing from the last only in having a well-defined, slaty or schistose structure developed in them. These are also, perhaps, a little coarser grained, and as a consequence of the schistose structure, are not nearly so tough under the hammer. This slaty or evenly schistose, black hornblende-rock, is usually the basal formation of the Keewatin series, and lies in contact with the granitoid gneisses. When the granites break through hornblende-schist, the latter may be either of the massive or the schistose variety of the black hornblende- General character.

schists. The term schist is retained for the massive variety, since, although of comparatively the same coherence in all directions, microscopically the crystals appear to have a parallel arrangement. Other varieties of hornblende-schists prevail, but they are usually green, of medium dark tint, and more or less chloritic. A few specimens of the more massive and less evidently hornblendic varieties of these rocks, have been examined, and an account of their microscopical characters will be of service in conveying an idea of the nature of an important and characteristic part of the belt of schists we are considering.

Specimen from Separation Point.

Section No. 41, is from a stratified rock on the end of Separation Point. The rock is not here a part of a hornblendic group, but is associated and interbedded with a series of agglomerate-schists, with which it is consequently grouped in the mapping. The banded structure described by Mr. Bayley as characterizing the section under the microscope, is true of the rock on the large scale, though the strata appear contorted. The following is his note on the section.—

"It is a banded horneblende rock. It consists principally of small, irregular pieces of fibrous green hornblende with a ground-mass of quartz arranged in some places in mosaic masses with irregular outline. The other constituents of the rock are small crystals of hornblende with twinned structure, a few plates of brown biotite, a small quantity of plagioclase almost completely changed into sassurite and a little pyrite.

"Under the microscope, the section examined shewed a distinct banding of layers containing varying amounts of hornblende. Macroscopically, however, it appears as an eminently massive rock. Hence it is impossible to decide, apart from field study, whether it is an amphibole-schist or a metamorphic eruptive rock."

Specimen from Big-stone Bay.

Section 12 is that of the tough, compact, fine-grained rock that occupies so extensive an area in the vicinity of Big-stone Bay, and forms the contact rock with the Laurentian granitoid gneisses along the eastern confines of the Keewatin area. The particular specimen examined is from near the shaft of the Pino Portage mine. It is described as resembling No.41. The minerals forming it are woven together, producing a compact, massive-looking rock. It is not quite so coarse grained as No. 41. There is a little more hornblende, which is darker and more fibrous. The plagioclase has been changed into epidote. A little quartz, with hornblende inclusions and small grains of magnetite scattered all over the rock, complete its list of constituents."

Rock from White-fish Bay.

The next specimen of these hornblende-schists, of which a section has been examined, is one typical of the schists in contact with the granitoid gneisses at the nort end of White-fish Bay on the southern

confines of the belt. It is taken from a small island near the narrows which lead from the bay out to the lake.

"Section 23.—This rock is very peculiar, reminding one of the 'feldspathic hornblende-schist' of Wichmann. It consists of parallel plates of green hornblende in a ground-mass of feldspar in irregular rounded grains, and sometimes in long crystals. This feldspar is fresh and some of the crystals are twinned according to the Carlsbad law. The hornblende is compact and feebly pleochroic. Grains of magnetite mixed with hæmatite occur here and there, staining the rims of the hornblende with a brown, ocherous stain. Apatite and sphene, epidote and very thin shreds of biotite occur in small quantity in the ground-mass. In addition to the comparatively small amount of plagioclase in the ground-mass, there are very large porphyritic crystals, apparently made up of several individuals. These porphyritic crystals have, in general, the outlines of a crystal of feldspar. The extinctions in the faces could not be measured in consequence of their polysynthetic nature. The different individuals are twinned. Those in the centre are perfectly fresh, while those near the edges are decomposed, the alteration products being sassurite, hæmatite, magnetite, quartz containing acicular crystals extinguishing at 40°–42°, and an indeterminate granular substance. Around the edges of this large crystal, the hornblende crystals are massed as if they had been pressed against it by some force acting perpendicularly to the planes of schistosity."

Specimen from near Wiley Point.

Section No. 1 is that of a specimen of a series of green hornblende-schists taken from an island three-quarters of a mile east-south-east of Wiley Point. The rock is peculiar in having contained in it pebble-like portions of a light-gray, felsitic material, the line of demarkation between which and the schistose hornblendic matrix, which constitutes the main mass of the rock, is very sharp. This is the "lighter portion" of the section referred to by Mr. Bayley, who writes as follows upon it.—

"Section No. 1 is very much like No. 23. The porphyritic crystals, however, are much smaller and are much more altered. The hornblende is much lighter in color and considerable biotite has been developed. The hornblende and mica are arranged in bands in a very fine ground-mass of feldspar and calcite. Almost all the plagioclase, both in the porphyritic crystals and in the ground-mass is entirely changed into sassurite. Titanic iron and leucoxene are scattered through the ground-mass.

"In the lighter portion of this same rock the plagioclase predominates and the hornblende is almost entirely lacking. In addition to the plagioclase, which, as in the darker portion, is highly altered,

there is considerable calcite, the two forming a ground-mass in which there are numerous grains of titanic iron. Most of these are surrounded by leucoxene."

Specimen from Wiley Point. About seventy-five yards south-west from the extremity of Wiley Point, the micaceo-feldspathic schists are cut upon the shore by an irregular intrusion, a dark, gray rock containing numerous sharply-defined porphyritic crystals of calcite, which, on the weathered surface, have been completely dissolved out, leaving angular rhombohedral cavities, which give the rock a peculiar pitted appearance. Mr. Bayley classes the rock with the schistose hornblende rocks, and thus describes it.—

"Section No. 3 is a sort of hornblende-schist with porphyritic calcite. The ground-mass is composed of fine grains of feldspar with slightly larger grains of hornblende, calcite, and a little biotite, titanic iron, and leucoxene. The plagioclase is dusty with inclusions and contains a few brightly polarizing needles. For the most part it is fresh and twinned according to a single law. The mica is brown, the hornblende, green. They are in about the same proportion, and together make up not more than a tenth of the whole rock. The calcite is in irregular grains, as if it were developed in cavities. The porphyritic crystals are all calcite. It forms perfectly developed rhombs, with very distinct cleavage lines. This calcite contains numerous inclusions of hornblende, plagioclase, both fresh and altered, titanic iron and other little irregular patches of calcite, which are often twinned. In addition to these, there are also inclusions of the fine-grained ground-mass and little quartz grains. The occurrence of calcite in this rock reminds one of the amygdaloids of Pumpelly and Irving."

Specimen from Yellow Girl Bay. Another rock classed by Mr. Bayley with the hornblende-schists is a very calcareous, greenish-gray schistose matrix of an agglomerate on the south side of the north-east arm of Yellow Girl Bay.

He says of it:—

"Section No. 20 is very much like Section No. 3. It contains a little quartz in the ground-mass. The plagioclase is sassuritized, and in other respects the rock is less fresh. In structure, the rock is eminently schistose. Quartz mosaics, aggregates of biotite and hornblende, mixed with hæmatite and magnetite, and oval masses of calcite all occur with their longer axes parallel. The calcite masses are comcomposed of twinned individuals. Titanic iron and leucoxene are scattered throughout the whole mass."

Diabases and Diorites.

Association with hornblende-schists.

Intimately associated with the schistose hornblende-rocks are great masses of dioritic and diabasic rocks, both schistose and massive. These rocks are for the most part interbedded with the hornblende-schists, sometimes regularly and at others in short non-continuous masses, such as might be expected as the condition of occurrence of ancient flows. For purposes of mapping it is impossible in the wild and uncleared state of the country to separate these diorites and diabases from the hornblende-schists into which, indeed, they seem at times to merge by gradations that make any attempt at a hard boundary quite out of keeping with the natural conditions.

Of these rocks, fourteen sections have been submitted for examination, an account of which will give a very fair idea of the representative kinds that are to be found in the area under consideration. These specimens are grouped by Mr. Bayley as follows, the detailed description of the sections corresponding to the respective numbers being given in the succeeding pages.

Classification.

DIABASES AND DIORITES.

	34. Typical diabase (augitic).
Typical "Greenstones." Altered traps.	27, 36. Entirely uralitized; structure "ophitic."
	35. " " structure partly "ophitic."
	19, 18. " " " wholly granular.
	30, 21, 22. Films of hornblende and sassurite.
	10, 16, 37, 25. Even more altered. Films of hornblende, sassurite and calcite.
	43. Typical diorite.

The rocks classed under this head, he remarks, form a regular series from the typical diabase (34) through altered diabases to the typical diorite (43).

Diabase of Falcon Island.

Section No. 34 is that of a mottled grey granular rock which forms a dyke sixty feet wide, cutting the Laurentian gneiss, with a strike due south, on the west side of Falcon Island, near the contact with the Keewatin. It seems not improbable that such a fissure in the gneiss may be only the exposed remnant of an extensive system of vents whereby the Keewatin trough was supplied with the volcanic material which now fills it, although the comparatively little-altered state in which Mr. Bayley finds the section examined by him, might suggest a very much more recent origin for it and give it a place in that series of basic dykes which cut both Laurentian and other rocks throughout the region, and perhaps equivalent in age to the trap overflows of Lake Superior. The following are its lithological characters.—

"The rock is a typical diabase. It consists principally of augite, hornblende and feldspar. "The augite is in large, irregular pieces, of a yellow-brown colour, with very distinct cleavage and full of colorless and brown glass inclusions. Toward the edges it shows a fine striation, and on the outer rim is changed into an apparently compact green hornblende which is strongly pleochroic. The plagioclase is in the usual lath-shaped crystals with twinned structure.

"The accessory minerals are dark biotite, very strongly pleochroic, mixed with magnetite and secondary hornblende. Secondary quartz with glassy (?) inclusions in some places fills the interstices between the feldspar. The plagioclase in the ground-mass is nearly all changed into sassurite, in which other minerals appear porphyritically. In addition to its alteration into hornblende, the augite is changed in many places into a fibrous grey mineral clouded with little black dots. The structure of the rock is that of a typical diabase."

Altered diabase Cork-screw Island.

The rocks on the southwest extremity of Cork-screw Island in Ptarmigan Bay are much broken by intrusions of flesh-red granite. The rock that the granite cuts in parallel dykes is very hard, dark and compact in texture, with considerable pyrites finely disseminated. The section of it that has been examined presents the following characters.—

"Section No. 27, though containing no augite, is evidently an altered diabase. The hornblende is fibrous, as if secondarily developed. The original structure can still be detected, where the decomposition has not gone too far. The ground-mass is composed of decomposed feldspar (principally kaolin), a little secondary quartz with numerous apatite crystals, and a few very fine needles polarizing in very bright colours. The hornblende is scattered all through this ground-mass thickest where the augite originally was. The plagioclase is in lath-shaped crystals which, in consequence of alteration, have lost almost all traces of twinning. Quartz (always secondary) occurs in irregular grains which, in polarized light, are found to be made up of numerous individuals forming a mosaic. Titanic iron and leucoxene are also present in abundance."

Altered diabase Devil's Gap.

The rocks exposed in the natural section afforded by the Devil's Gap near Rat Portage, are extensive masses of greenstone, with a felsite schistose structure developed in it in places, which seem to be interbedded with hornblende-schists. The more massive rock graduates into the distinctly laminated schists towards the south end of the Gap, so that it is impossible to draw a hard line between them. The massive greenstone is thus described :—

"Section No. 36, is also an altered diabase. Here the diabase is very pronounced. The augite, as in No. 27, is entirely replaced by light-green, fibrous hornblende (uralite). The plagioclase is in lath-shaped

crystals, which are brown from little inclusions. These inclusions are often heaped up in the centre or arranged around the rims of the crystals, which in other respects are perfectly clear and fresh. In other respects this rock is like No. 27, except that the titanic iron is almost entirely replaced by leucoxene, and in many places calcite has developed in the neighborhood of the plagioclase."

Section No. 35, is that of a specimen of a considerable thickness, of bedded crystalline trap-rock, which crops out upon the shores of the lake near Rat Portage, just to the south, and crosses the Canadian Pacific railway track, with an east-north-east strike, almost two miles east of the town. These trap beds are seen on the lake shore to dip north at a high angle, under beds of grey, very quartzose mica-schist, and to be in contact to the south, or in their upper portion, with beds of agglomerate. The specimen is from the cutting on the railway track. Altered diabase Rat Portage.

"Section No. 35 is much coarser grained than No. 36. It consists principally of larger, irregular grains of beautifully fibrous hornblende and crystals of plagioclase. The hornblende is highly pleochroic, $\mathfrak{c}$ = blue-green, $\mathfrak{a}$ and $\mathfrak{b}$ = greenish-yellow, and comprises about two-thirds of the entire rock. The plagioclase occurs in two forms. The lath-shaped crystals are perfectly clear, and show the twinning lamellæ very distinctly. Some are brown, with inclusions, as in No. 36. That in the ground-mass is commencing to change into sassurite. The diabase structure is discernible only in a few places. Titanic iron and leucoxene are developed around the hornblende."

Section No. 19, is, from what appears to be a great interbedded sheet of trap, associated with hornblendic or micaceo-hornblendic schists, mica-schists and agglomerates, on the north-east arm of Yellow Girl Bay. Its characters are thus given.— Trap, Yellow Girl Bay.

"The rock contains no trace of diabase structure. It is very coarse-grained. The hornblende is very fibrous, and bears all the marks of secondary development. It is highly pleochroic, $\mathfrak{c}$ = blue-green, $\mathfrak{b}$ = grass-green, $\mathfrak{a}$ = greenish-yellow. Long, slender needles penetrate into the surrounding ground-mass. The plagioclase is clear and in long crystals. Leucoxene is very abundant. Its development by alteration of titanic iron is very finely seen here. Large octahedrons are composed of mixtures of leucoxene and titanic iron in all proportions, and sometimes all traces of the original mineral have disappeared, leaving pseudomorphs of leucoxene. A little secondary quartz occurs in veins and mosaics."

Along the north shore of the Grande Presqu'île in the neighborhood of the White-fish Bay Narrows, is a great thickness of light-green trap of varying texture, but for the most part coarsely crystal- Trap, White-fish Bay Narrows.

line. Stratigraphically, these traps occupy an intermediate position between the black hornblende-schists, that are in contact with the granitoid gneiss to the south, and a higher formation of softer, fissile, lighter green, chloritic, hornblende-schists, which lie upon them to the north. The characters of a specimen of this trap are as follows—

"Section No. 18 is less fresh than No. 19. The hornblende is very light green, and feebly pleochroic. Long, almost colourless needles extend far into the plagioclase of the ground-mass. Most of the triclinic feldspar is entirely changed into sassurite. That which has not undergone alteration is present in thin lath-shaped crystals. As in most of the other rocks of this series, quartz also occurs here in mosaic grains, filling in the interstices between hornblende and plagioclase. It is perfectly clear and contains apatite crystals (almost certainly of secondary origin). Leucoxene and titanic iron are also present. Besides these, there is a brownish mineral with very indistinct cleavage. It polarizes like an aggregate and appears to have undergone alteration of some kind. Its nature could not be determined without a chemical analysis."

Trap from Big Narrows Island. Section No. 30 is from a mass of trap occupying the extremity of a point on the north shore of Big Narrows Island. It is in contact to the south with an agglomerate-schist, which dips to the south, and the trap is probably intercalated as a thick bed in it, though the evidence afforded by the exposure does not preclude the possibility of its being an intrusive boss. It is thus described :—

"The section contains no traces of diabase structure, not even a clearly-defined plagioclase crystal. It is more altered than any of the rocks heretofore considered. The hornblende is in patches all over the slide. It is light green and feebly pleochroic. The feldspar is entirely changed into sassurite, except in the case of a few porphyritic crystals. This sassurite, mixed with the hornblende, forms a ground-mass in which a large quantity of calcite, some of it in long, lath-shaped crystals surrounded by a brown rims, occurs. This calcite is evidently a pseudomorph after plagioclase, and if this is the case, the rock would probably be classed among the rest of this group as an altered diabase, although no crystals of plagioclase remains. In addition to these constituents, there also found in this rock quite a quantity of yellowish epidote in irregular masses, slightly pleochroic, a little sphene, and the usual leucoxene and titanic iron."

Trap, Yellow Girl Bay. Section 21 is from the rock occupying the extremity of the point that separates the two arms of Yellow Girl Bay as a thick but not very well-defined bed in green schists. The rock itself, though coarse-textured and massive in aspect, displays a tendency to rough cleavage under the hammer.

"It is much more highly altered than No. 30. It consists of a ground-

mass composed of irregular masses of decomposed plagioclase, a little secondary quartz and considerable calcite, filling in interstices between plagioclase. The hornblende is in large, irregular fibrous plates and in small, well-developed crystals. The former are bluish-green and yellowish-green bleached on the edges to a perfectly colorless mass of fine, long needles. The latter seem to have been developed from the former, for they only occur in places where the larger plates have evidently been subjected to some decomposing agency. Here they are more ragged and of a brighter color than in any other portion of the rock and are always accompanied by titanic iron and sphene. The cross sections of the smaller crystals shew the cleavage lines and characteristic prismatic angles. Small plates of brown biotite occur mixed in with the hornblende, and apatite needles are scattered through the ground-mass.

"In all these highly altered rocks considerable calcite is developed through decomposition of the oligoclase."

Section No. 21 is from the rock of Rendezvous Point at the entrance to White-fish Bay. It is another specimen from the great trap formation described under No. 18. It is briefly described as being "even more decomposed than No. 21. The hornblende is not bleached quite so much and the smaller crystals are twinned. The plagioclase is altered to a considerable extent into sassurite, which, mixed with the fine needles of hornblende, give a granular appearance to the ground-mass. In all other respects this rock is like No. 21." Trap, Rendezvous Point.

On a small island, about half-way between Pine Point and Heenan Point, an interesting association of rocks is met with. On the west side of the island are greenish-grey, rusty-weathering, fissile, chloritic schists. The strike of these schists bends from N. 30° E. to N. 20° E. going north and dip westward at angles varying but little from the vertical. At the north end of the island, the same schists are of a darker green colour, firmer texture, less fissile, and much less decomposed, so far as can be judged from microscopic examination. They are in contact to the east with a grey-green trap in a line parallel to the strata of the schists, and on the west with a bed or dyke of mottled, green, granular, crystalline trap, through which run small seams of an asbestiform mineral, whose fibrous structure is perpendicular to the vein-walls. This "greenstone" is in contact again to the west with a large vein-like mass of rusty-weathering, green, somewhat silicious limestone. The green schists have a thickness of about sixty feet; the grey-green trap to the east twenty feet to the water's edge; the mottled green trap about forty feet and the limestone an undefined thickness, but probably about twelve or fifteen feet. The microscopic characters of the limestone are given on page 60 C C. The mottled green trap is thus described.—

"Section No. 10 is similar to Nos. 21 and 22. The hornblende is a little lighter in colour and the colourless needles are longer and finer. Titanic iron and leucoxene are scattered all through it, and now and then a little crystal of hæmatite is discovered in it. Calcite, as usual, is not an infrequent constituent of the ground-mass."

From Andrew Bay.

Section No. 16 is that of a rather coarse-textured, mottled, green and white rock, from the north side of the east end of Andrew Bay. It is associated with hornblendic schists and is probably a bedded mass. It is noted as "Very much altered. Plagioclase originally predominated, but this has almost entirely changed into sassurite. Now and then a very opaque crystal remains that has not been completely altered. The hornblende is in comparatively small quantity. It is very light green and feebly pleochroic. Associated with it are spheno and leucoxene. Considerable calcite occurs in the ground-mass."

From Labyrinth Bay.

Section No. 37 is from the south side of a long island in Labyrinth Bay, and is found along the shores of the Shoal Lake Narrows at intervals in apparently thick-bedded masses associated with other greenstones, schistose and massive, and serpentines. The rock has a coarse but distinctly marked gneissic foliation of the hornblendic constituent. "It is even more altered than No. 16. All the plagioclase has disappeared and in its stead are lath-shaped, almost opaque aggregates of sassurite and other decomposition-products. The hornblende is very pale, almost colourless. Titanic iron, leucoxene and calcite are disseminated everywhere throughout the ground-mass, the first two especially in the neighborhood of the hornblende."

Section No. 25 is a third specimen of the trap formation noted in connection with Nos. 18 and 21. It is in the same line of strike as both of these and is about two miles to the west of the locality from which No. 18 was taken. A distinct schistose structure is developed in the rock in places and the schistose variety passes into the massive by almost insensible gradations.

Microscopically, Mr. Bayley notes that "it is also similar to No. 16. The hornblende is a little darker and more pleochroic. It is also much more fibrous, and in some places is covered with little grey dots."

On a point on the south east side of Windigo Island, about its middle, occurs a patch of coarsely angular dioritic breccia breaking through the granitoid gneisses that make up the greater portion of the island. A light grey, highly feldspathic mottled matrix holds sharply angular, mechanically broken fragments and blocks of a dark, almost black, rather finely textured rock, composed apparently chiefly of hornblende. Mr. Bayley's examination of a section across a contact of matrix and inclusion shows both to be essentially diorites, in the former of which feldspar predominates and in the latter hornblende. The included frag-

ments are probably portions of earlier eruptions or flows from the same vent that have solidified and been caught up as broken pieces by later and more feldspathic lavas. Its lithological characters in detail are thus given. Diorite from Windigo Island

"Section No. 43. A typical diorite, consisting of irregular grains of plagioclase and dark-green, massive hornblende.

"The hornblende is compact $\mathfrak{c}$ = very dark black-green, $\mathfrak{a}$ and $\mathfrak{b}$ = yellowish-green, accompanied by irregular grains of pink-yellow sphene, and light-green epidote, with very little biotite around the edges, and a brown, granular mineral in rhombohedrons, the nature of which could not be positively ascertained. The plagioclase is fresh and shows beautiful twinning lemallæ, all of which, in some crystals are according to a single law, while in others both laws are followed and the lamellæ cut each other at an angle of 86°–87°. A small part of the plagioclase begins to shew a non-polarizing decomposition-product in the centre of the various crystals, as if it had begun to decompose around central inclusions. Apatite needles occur throughout the plagioclase and other constituents of the rock in large numbers.

"The slide examined was composed of two distinct portions, one very dark and the other very light, as if it were the contact of two distinct rocks. A microscopical examination, however, shewed that both portions could be considered as diorites. In the dark part, hornblende predominated, and the plagioclase was generally fresh. In the light part, plagioclase (oligoclase) predominated, and it was more decomposed. The structure of the rock is that of typical diorite."

In this collection of rocks, classed by Mr. Bayley as diabases and diorites, an interesting fact comes out, when their lithological characters are considered in connection with their conditions of occurrence in the field. This is that the extremes of his series, the typical diabase and the typical diorite, are erupted rocks cutting the granitoid gneisses beyond the limits of the Keewatin area, while all his transitional rocks, the "altered traps" are within that series, and occur apparently as bedded flows of volcanic origin, intercalated irregularly with sedimentary deposits. This distinction, so well-marked both in the field and under the microscope, points to a later and distinct origin for the typical rocks, and as has already been suggested on a previous page, they are possibly associated in age with the trap overflows of post-Archæan times, which had, as the seat of their greatest intensity, the Lake Superior basin, but which may have been manifested to a less degree over a region of wide radius. Microscopic distinction between intrusive and bedded volcanic rocks.

The typical diorite, though placed at the extreme of a series of rocks classified according to their degree of alteration from an original diabase, cannot be regarded as having been derived from a diabase as

the "altered traps" are. It is in itself a rock of equal systematic importance with the diabase, and in this particular instance it seems to have suffered as little alteration from its original condition as the diabase at the head of the series. On the other hand, the manifestly altered and degenerate condition of those bedded traps of the Keewatin indicate, according to accepted notions of lithology, a much greater age, the degeneracy from the type being apparently a function of time to a great extent.

Serpentines.

This interesting class of rocks is not of extensive occurrence in the Keewatin area of the Lake of the Woods, but is found irregularly distributed in patches of rather ill-defined character and extent. Specimens of the serpentine occurring in association with the quartz-porphyry to the south-west of Wiley Point have already been described. On the island and shore of Shoal Lake Narrows serpentine is more largely developed than elsewhere in the region. It is associated with altered trap-rocks and hornblendic schists. A specimen of this serpentine is thus briefly described by Mr. Bayley :—

Microscopic characters.

"Section No. 38 is a typical serpentine. There is no trace of the original minerals from which the present rock was derived. The whole ground-mass is composed of serpentine fibres, without any regard to the crystalline form of the original mineral. In this ground-mass, chromite, magnetite and a hydrated iron oxide occur."

On the south side of Brick Island a boss of serpentine projects through the black hornblende-schists in the immediate vicinity of their contact with the gneiss (section No. 4.) The microscopic characters of this rock are thus given :—

"Section No. 5.—In this slide, considerable af the original olivine can still be detected. It is in large oval grains. These are broken into numerous pieces and in the cracks serpentinization has begun to take place. A fibrous, colourless mineral, which in all probability is enstatite, has also given rise to much of the serpentine. This mineral contains numerous inclusions of magnetite, and has, as nearly as could be determined, a parallel extinction.

"Under the microscope, with crossed nicols, the slide is seen to be made up principally of serpentine, with large inclusions of broken olivine and irregular pieces of enstatite. In addition to these, there is considerable chromite, hydrated oxide of iron, hæmatite and the gray, opaque substance noted in section No. 32. Mixtures of these substances mark the outlines and cleavage lines of the original minerals."

Impure serpentines or soapstones occur in a few localities, most characteristically, however, on the narrows to the south of French Portage. The soapstone or pipestone of Pipe-stone Point is simply a soft, decomposed, or steatitic variety of the green hornblendic schists, and is not used by the Indians for making their pipes.

Clastic Rocks—Agglomerates.

Closely allied stratigraphically to the last group of rocks are the fragmental rocks, agglomerates, tuffs and boulder-conglomerates of the Keewatin series. These, in many places, merge directly into mica-schists, on the one hand, and through green, dioritic schist-agglomerate into hornblende-schists. This mergence is not due to any process of alteration or metamorphism. Although the rocks pass into one another in space, it cannot therefore be assumed that there has been an historical passage or change of one rock into the other. The mergence is due simply to gradually increasing differences in the conditions and material of deposition, either on the same horizon (in which case the conditions and material have varied with the place), or at different stages of the stratigraphical column, when they have varied with time of deposit. Metamorphic agencies, have, to a limited extent, affected the mineralogical constitution of these rocks, but have by no means destroyed or effaced their original characteristic differences. Rapid mergences from one class of rock-material to another are easily explicable upon the only hyposthesis that will afford an adequate explanation of the origin of this geological series, viz.: an extremely rapid process of deposition of intimately associated, and often alternating volcanic ejectamenta (both flows and tuffs) and aqueous sedimentation, the material for which was derived partly from the volcanic products and partly from the more silicious or acidic rocks which seem to have constituted the original floor of the trough. The development of secondary minerals in these different classes of rock-materials, and the effects of pressure upon their internal structure have left them quite as distinct one from the other, in spite of the transitional mergence as when originally deposited. Association.

The effects of pressure upon the coarser varieties of these fragmental clastic rocks are well defined, and are extremely suggestive of the general diminution of the thickness of the rock mass, in directions parallel to the folding, which the series has undergone. The included fragments of the agglomerates are nearly always more or less flattened or lens-shaped, the greatest planes in the fragments being parallel with the planes of schistosity, which are in the great majority of cases ob- Effects of pressure on agglomerates

servably identical with those of the bedding. This lateral flattening or pulling out of these fragments is most characteristic of those of smaller size, say under six inches in diameter, when their original outlines are, for the most part, though not always obliterated. Large, fragments, varying in size from six inches to three or four feet in diameter, are not uncommon, and succeed better in retaining their original shapes, which seem to have been mostly angular. In a few instances I have made sketches of the shapes of some of the included fragments, to shew their broken or angular character, some even presenting in the excellent cross sections afforded by ice-polished surfaces, re-entering angles. On the north side of Big Narrows Island, these agglomerates are extensively developed, and the matrix or paste is principally a schistose greenstone, of rather heterogenous composition. The accompanying figures are typical of the shapes of the more angular fragments, the lenticular ones, however, preponderating.

FIG. 3, ILLUSTRATING THE ANGULAR SHAPES OF FRAGMENTS IN AGGLOMERATE-SCHIST, BIG NARROWS ISLAND.

Matrix and fragments similar.

Here, as elsewhere in these agglomerates, the included fragments appear to differ but little in composition and texture from that of the matrix, from which they are distinguished principally by a whiter or more yellowish, weathered surface, indicative of a higher proportion of constituent feldspar, and by a superior hardness which cause them often to project above the surface.

Fragmental rocks showing water action.

Fine boulder- or pebble-conglomerates, distinctly recognizable as such, are of comparatively rare occurrence and of limited extent, and seem to be only phases of the more abundant agglomerate in which shore action has come into play and rounded the fragments before their final enclosure in the paste in which they are embedded. These pebble- or boulder-conglomerates merge into the ordinary volcanic agglomerates. They are of two kinds, (1) those in which the pebbles are crowded close together with a very small proportionate amount of cementing material, and (2) those in which the pebbles are widely separated and the paste is a dark-green, fissile, soft, chloritic schist. They differ from the agglomerates chiefly in the fact

that, whereas in the latter the paste and included fragment are closely related in composition, in the conglomerates, the pebbles are distinctly of a different origin and composition from the paste, the pebbles being chiefly round or oval, smoothly worn pieces of felsite, while fragments of saccharoidal quartz are also not uncommon. The best instance of these conglomerates was observed on the north side of Crow-duck Lake. Good instances of pebble-conglomerates also occur near Point Aylmer and at Crow Rock channel.

By far the greater portion of the agglomerates, which constitute one of the most extensive rock formations of the area, seems to have been formed quite independently of shore action. Both paste and included fragments have evidently had a common origin, and been laid down together, perhaps not even always under water. At times, as on the west side of Middle Island, the paste itself appears to be altogether composed of angular chips or fragments of felsitic and trappean material, varying from one-eighth to one-half an inch or more in size, constituting a genuine volcanic tufa in which the larger lenticular and angular fragments are imbedded. When this is the character of the paste, included fragments of angular forms are more plentiful. Fig. 4 shows the shapes of a number sketched from the agglomerate on the shores of Johnston Channel, north of Falcon Island. Agglomerates generally quite angular.

FIG. 4.—ILLUSTRATING THE ANGULAR SHAPES OF FRAGMENTS IN AGGLOMERATE-SCHIST, JOHNSTON CHANNEL.

These agglomerate-schists are often garnetiferous, and the presence of garnets is particularly characteristic of the more micaceous variety on the islands north of Falcon Island.

Closely associated in appearance with the more lenticular varieties of these agglomerates is an apparently concretionary structure, which, from its occurrence in traps in other regions, has given to the rocks so characterized the name of "concretionary traps," although the structure is by no means confined to true traps. The association of this concretionary structure with the lenticular agglomerate is more than one of mere appearance, for it is most largely and most characteristi- Concretionary structure.

cally developed in rocks closely similar, as far as microscopical characters go, to the rather nondescript greenstone-schist that constitutes the paste of those agglomerates in that form alluded to as the dioritic schist-agglomerate. It is also found developed in amygdoloidal trap-schists, and in dark-green or black hornblende-schist. This structure consists in the rock being divided into more or less irregularly spherical or ovoid masses, varying in diameter from two or three inches to as many feet. These ovoid masses are not in close contact, but are separated from one another by an interstitial material. The concretionary masses are, at their points of nearest approximation to one another, generally about half an inch or an inch apart, no matter what may be their size, so that when the ovoid masses are large, the interstitial material appears in section as thin anastomosing sheets, in which is developed a schistosity parallel to the outlines of the ovoid masses they enclose. This interstitial filling is generally of a darker color, more chloritic, softer, and of a finer more homogeneous texture than the ovoid masses, and weathers out, often leaving the latter, in the sections afforded by glaciated surfaces, surrounded by sharp, little trenches.

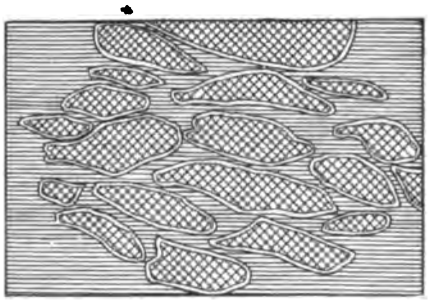


FIG. 5.—ILLUSTRATING CONCRETIONARY (?) STRUCTURE IN ROCKS ON KENNEDY ISLAND.

Section at Kennedy Island.

Fig. 5 represents the appearance presented in a natural horizontal section on the south-east corner of Kennedy Island. The rock is in the line of strike of a body of agglomerate-schists, into which it apparently merges and the paste of which it strongly resembles, although in some places the agglomerate in turn merges into a pebble-conglomerate with little or no well defined paste.

The ovoid masses are uniformly arranged as regards the direction of their long axes, and each one is surrounded by a sharp border, half an inch wide, of a dark greenish-grey color, which has been more resist-

ant to weathering agencies than the rest of the rock. The ovoid masses present, as the result of weathering, a rough or pimpled surface of porous aspect and bleached greenish-white colour. The interstitial filling is firmer in texture and softer than either the ovoid masses or their border, and is intermediate between them in color, with a brownish-yellow tinge.

In the hornblende-schists, this ovoid structure in the rock takes a somewhat different aspect, and presents the appearance of thin anastomosing sheets of dark-green, soft, chloritic material, sometimes enveloping completely ovoid or irregular-shaped portions of the hornblende-schist, and at others losing themselves in a tapering, disconnected fashion in the main mass of the rock. Fig. 6 represents a section afforded by a glaciated surface on Egg Island, in black, glistening hornblende-schists, which are in contact to the east with westerly-dipping mica-schists. Concretionary hornblende-schists.

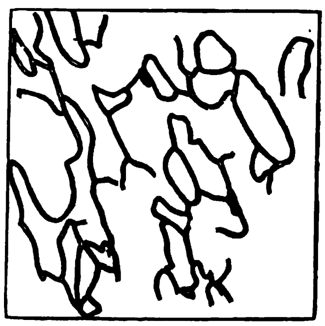


FIG. 6.—ANASTOMOSING CHLORITE VEINS IN BLACK HORNBLENDE-SCHIST.

A fairly typical example of the coarser varieties of these fragmental rocks is taken from the narrows between the main shore and Coney Island, near Rat Portage. It has been examined by Mr. Bayley and its microscopic characters is thus given by him.— Fragmental rocks.

"Section No. 26 is made up of broken fragments of orthoclase, plagioclase, round grains of quartz, which, between crossed nicols, seem to be made up of numerous smaller grains and fibrous hornblende in a micro-crystalline ground-mass of quartz and feldspar. Small plates of brown biotite, hornblende, little crystals of hæmatite, magnetite and apatite are disseminated all through the ground-mass. Microscopic characters.

"The structure of the rock is highly schistose, and in the schist-planes secondary green hornblende and mica are everywhere developed. Aggregates of hornblende, mica, magnetite and hæmatite occur with their longer axis parallel to the schist-planes. The fragments of

feldspar are generally fresh, but a few are decomposed with the production of sassurite. The rock is probably a conglomerate, which has undergone partial metamorphism."

Section No. 29 is that of a rock associated with micaceous schists and coarse agglomerates, occurring on the shore about two miles south-west of Wiley Point. Microscopically, it is described as "very much like No. 26. The ground-mass contains very much more secondary hornblende. The pieces of feldspar are small, and much more altered (principally into sassurite), and considerable green epidote has been developed.

"There is almost no biotite and the schistose structure is just barely evident. A little secondary calcite has been found in the interstices around the altered plagioclase."

Paste of agglomerates.

Section No. 13, from Bald Island, may be taken as representative of the paste of the agglomerate rocks so largely developed on the south side of Andrew Bay. Associated with them on the same island, in apparently conformable stratification, is the felsite described as section No. 17. The fragmental rock, as described by Mr. Bayley, "contains rounded grains and broken fragments of palgioclase, (often altered) orthoclase and quartz, held together by a mosaic cement of quartz and feldspar, most of which has become sassuritized. In this ground-mass there is considerable green fibrous hornblende and a little in well developed crystals. This may have been formed secondarily and crystallized *in situ*.

"In addition there is carbonaceous matter, leucoxene and titanic iron. Calcite in irregular grains and bleached hornblende also occur in the cement."

On the south-west side of Echo Island occurs a rock which appears to be microscopically similar to the last, although there is no marked agglomerate structure observable in it microscopically. In the field it is associated with and apparently merges into an argillite or clay-slate and is in contact with a felsitic schist.

A section of this rock, No. 14, is briefly noted as being "very similar to No. 13, except that it contains more mica and very much less hornblende. Very little feldspar occurs in broken fragments, most of which consist of clear quartz without inclusions, except in rare cases, when they are very small fluid inclusions."

Mica-schists, Micaceous slates, Clay-slates and Quartzites.

Association.

These appear to constitute on the Lake of the Woods a natural group of rocks intimately associated, both as regards their origin and their present relations in the field. Their stratigraphy and distribution will

be considered further on, but a few words may be said as to their lithological characters. The clay-slates vary from hard compact argilites to the readily cleaving blue-black slates of commerce, the one passing into the other and merging into glossy micaceous slates.

The mica-schists present considerable variations in texture and in the relative proportions of quartz and mica, entesing into their composition. A typical example has been sliced and reported on by Mr. Bayley.

Typical mica-schists.

"Section No. 2 is a mica-schist. It consists of a mosaic ground-mass of quartz grains without inclusions. Small, brown, highly pleochroic scales of biotite are arranged with their long axes parallel. Large pieces of muscovite occur in various positions without regard to the schist-planes, often crossing these, and including within themselves numerous of the smaller biotite scales and a few zicon crystals. In addition, there is scattered through the ground-mass a small quantity of epidote and calcite."

Various classes of mica-schists.

Mica-schists of this character often merge directly with agglomerate-schists in which the inclusions in the schist matrix vary but little from it in composition, and are generally lenticular in form, though not unfrequently quite irregular or abruptly angular in shape. It is not uncommon to find in these mica-schists a small proportion of feldspar, which gives them the character of finely laminated gneisses in places. As a general rule the proportion of mica in all the schists is small, and its almost total absence in many cases gives rise to quartz-schists and quartzites, which often shew a very distinct bedded arrangement. More massive quartzites of dark, greenish-gray colour occur on the south-east side of Shoal Lake, and interbedded with the felsites of the felsitic and hydromica groups of rocks, there are occasional bands of quartz rock of a flinty texture.

Glossy schist.

Sometimes mica-schists of the harsher varieties, consisting of quartz and mica, are found along the same line of strike to pass into fine-texturod, glossy schists. Of these, Section No. 24 is an example, from a point on the shore of the lake two and a-half miles south of Yellow Girl Point.—

"The schist is probably a metamorphic clastic rock. It consists of a very fine-grained ground-mass, containing little plates of brown biotite and shreds of green hornblende. Throughout this microcrystalline ground-mass are scattered irregular pieces of kaolinized feldspar, porphyritic crystals of the same mineral with beautiful zonal structure, fresh plagioclase, with twinning lamellæ, crossing at the angle of 86°, and irregularly shaped grains of limpid quartz, with club shaped intrusions of the ground-mass. The accessory minerals are apatite, pyrite, hæmatite, titanic iron and leucoxene."

Reasons for associating these rocks on map.

There exists the same difficulty of drawing hard lines between the argillites, mica-schists and quartzites, for purposes of cartography, as occurs in the case of the hornblende-schists and the various trappean rocks with which they are associated. Their characters are, in typical specimens, sufficiently distinct to make their separation on purely petrological ground an easy and desirable matter, but stratigraphically, they are so closely associated that in a field such as that of the Lake of the Woods, where exposures, though unusually good, afford access only to a fractional portion of the rock-surface, it is considered better, and more in accordance with our actual knowledge, to group these rocks under one colour.

Felsitic, Sericite, and other glossy fissile Schists of a Hydromicaceous or Chloritic character, with some Carbonaceous schists.

Association.

The petrological characters of the rocks of this natural group are in a general way conveyed by their names. A detailed account of them is, however, rendered difficult and unsatisfactory by their great susceptability to decomposition. If we except those schists which are strictly felsitic in composition, the rocks of this group are more profoundly decayed than any others in the area under consideration. The felsitic, hydromica and chloritic schists are generally intimately associated with the agglomerate rocks, into which they merge both across and along the strata, and their evenly bedded disposition leaves little doubt of their having been laid down by a process of sedimentation of some kind, the material, however, having been probably originally volcanic.

Felsitic schists.

The felsitic schists are of two general kinds, a whitish-weathering, fine-textured, compact, grey rock, usually distinctly bedded, but not particularly schistose, and a yellowish-weathering, fine-textured, very schistose rock, generally characterized by a greater or less abundance of quartz in isolated, large, clear grains of irregular shape and by a waxy lustre on the cleavage fracture. Both of these rocks merge into and become the paste of very distinct agglomerates, and these by the presence of hornblendic minerals in varying quantities blend with the green dioritic schist-agglomerate. The second or more fissile variety of these felsitic schists appears to merge on the other hand into true white, or nacreous, glossy sericite-schists of very fine, even texture.

Felsite from Labyrinth Bay.

Two of the sections of the more massive variety of these felsites have been examined by Mr. Bayley, who says of one from the south side of Labyrinth Bay :—

"Section No. 39 is very much like No. 42, except that it is more altered. The plagioclase has been almost wholly altered into sassurite, and the larger part of the orthoclase into kaolin. The decomposition has not gone quite far enough, however, to eliminate all traces of twin structure. This slide contains no mica, but a very little green hornblende and a few irregular grains of titanic iron remain, but most of it has been changed into luecoxene. This in most cases surrounds a central kernel of the titanic iron. In rare cases the original form of the crystal is preserved."

"The constituents of this rock appear to give slight indications of a schistose arrangement, but as it is impossible to decide positively as to this merely from a microscopical examination of a single slide, it has been thought best to include this rock among the felsites, where it certainly belongs if we are to be guided by microscopical structure and mineralogical composition."

Felsite from Bald Island.

"Section No. 17 (from Bald Island) is an altered felsite, very much like No. 39. It consists of a fine-grained ground-mass of clear quartz and kaolinized orthoclase, with a few larger, irregularly shaped grains of quartz, crystals of sassurite, ragged plates of light-green hornblende, a little biotite, titanic iron, surrounded by leucoxene, and needles of apatite. The whole ground-mass is filled with miciolites of muscovite."

Felsite from Big Narrows Island.

Section No. 7 is a felsitic schist of the more schistose variety from the eastern extremity of Big Narrows Island, where it constitutes the matrix of a felsitic agglomerate. It is described as "a quartz porphyry. The ground-mass of this rock is very similar to that of those noticed in Nos. 44 and 28. Instead of magnetite the rock contains pyrite, which, by its decomposition, stains the surrounding minerals a reddish-brown. Titanic iron, leucoxene, rutile in needles and yellow biotite in shreds occur. The porphyritic crystals are principally water-clear dihexahedrous of quartz. They contain inclusions of the ground-mass and very fine black dust. Many of them have been eaten into by the matrix, leaving a crystal into which has penetrated a large club-shaped portion of the crystalline ground-mass. They also contain large numbers of negative crystal-cavities containing movable bubbles. The feldspar is decomposed and very cloudy."

Serecite-schists

As a type of the sericite-schists, a specimen may be taken from a narrow band of these rocks on the south side of Tranquil Channel, lying between the agglomerate and the harsh quartzose mica-schists, which occupy the north side of Toad-stool Point. Macroscopically it is a nacreous, very fissile, glossy schist. Microscopically, "the section (No. 8) consists of a fine-grained, ground-mass of quartz, in which are plates and shreds of sericite, broken pieces of orthoclase, and plagioclase, rounded and irregularly shaped grains of limpid quartz, with liquid inclusions in lines, and considerable calcite, especially near the feldspar.

"Around the larger crystals are pressed coatings of a very light-green mica, which envelopes the crystals for about two-thirds of their periphrey. Little plates of chlorite, brown mica, hæmatite and magnetite, mingled together, mark the position held originally by some mineral from which they have been derived by decomposition.

"This rock must evidently have been originally clastic, and then have undergone metamorphism, during which the sericite and crystalline ground-mass were developed."

Carbonaceous schists. The existence of schists of an eminently carbanaceous character in the Keewatin series of rocks, is a fact of considerable geological interest They occur in bands rarely more than 15 to 20 feet wide, in soft, very fissile, grey hydromicaceous schists, into which they merge, across the strike, by a decrease in the proportion of carbon present, till that element, as a coloring constituent of the rock at least, disappears. A mergence into the hydromica-schists *along* the line of strike has not been observed. The greatest apparent continuity that I have observed for these black carbonaceous schists, is a distance of about half a mile, on the south side of Zig-zag Point. The schists are dull black in colour, and are slaty rather than schistose, breaking sometimes with an earthy fracture, and sometimes in splintery fragments. The essential character of the schist varies from a slightly carbonaceous variety of the glossy hydromicaceous slate to a black, argillaceous slate, which soils the fingers on handling. These carbonaceous schists are characterized by two features which have never been found wanting in them wherever observed. There are (1) a well-defined vesicular structure, and (2) an abundance of pyrite. The vesicular structure is so strongly developed in some portions of the schist that it presents the appearance of a very scroiaceous slag, the vesicles ranging in size from cavities an inch or more in diameter, to those of quite minute dimensions. The great majority of these cavities are spherical in shape, and the larger ones, which offer facilities for close examination, are seen to be continuously lined with a layer of white, translucent quartz, from a thirty-second to a sixteenth of an inch in thickness. These quartz-lined cavities, when broken across the middle, are found to be perfectly empty. They appear not to have been subjected to pressure, and must consequently have been developed in the schists after the period of pressure and folding. The smaller cavities, under a quarter of an inch diameter, do not appear, as a rule, to be lined with quartz, although some are, but are very generally filled with round balls of iron pyrites, which, with a little patience, can be pricked out of the schist in handfulls. These spherules of pyrite can be seen in all stages of decomposition, from comparatively fresh, bright-yellow, hard, little balls completely filling the

Vesicular character.

cavity, to mere little aggregations of ochre in the middle of the cavities, which, in many cases, under the influence of weathering, have been removed, and left the rock with a vesicular or scoriaceous aspect. Those cavities that are perfectly lined with quartz, do not seem to have ever been fillèd with pyrites, for apart from the difficulty of conceiving of its removal from the cavity through the layer of compact quartz, the lining is white and smooth, and is not rusted or stained in any way, as it must inevitably have been had it ever contained a kernel of pyrite. These vesicles or cavities seem thus to have constituted moulds in which, when an impenetrable lining of quartz did not prevent it, the spherules of pyrites have been deposited from solution. In the same schists pyrites is often present in large vein-like masses of such extent as to be of prospective economic value.

A satisfactory explanation of the origin of the vesicular structure in these schists is difficult to find. If the vesicles were not so perfectly round, and in many places so thickly crowded together, we might resort to the ordinary explanation of the solution and removal of some mineral contained in the schist, whereby cavities were formed. The perfectly spherical shape of many of the cavitees and their eminently scoriaceous aspect, irresistably suggest the agency of a confined gas or vapor acting upon a more or less yielding mass as concerned in the development of this curious structure. Origin of vesicular character.

Little seems to be gathered as to the history of the rock from its microscopic characters. An examination (Section No. 46), shews it to "consist principally of carbonaceous material, in grains and irregular masses, arranged to some degree parallel to the schist-planes. The other constituent is quartz, in grains, and here and there in little mosaics." Microscopic character.

An analysis of a specimen of this schist by Mr. Frank Adams shewed it to contain 5·773 per cent. of carbonaceous matter.

The presence of this carbonaceous matter in schists, which form part of a group of rocks, regarded by littrologists as altered sediments, is of the greatest possible interest in its bearing upon the question of the earliest appearance of processes of elimination of carbon in the free state at the surface of the earth.

Limestones.

The few dolomitic limestones that are found upon the Lake of the Woods seem to be of the nature of vein-stones, rather than bedded strata. No deposits of any considerable extent were observed, the largest being not more than twenty feet in thickness. The more fissile and decomposed portions of the hydromicaceous and chloritic group of Occur generally as vein-stones.

schists are characterized by the presence of numerous lenticular or stringer-like segregations of yellowish crystalline dolomite. These stringers are for the most part parallel with the cleavage-planes of the schist, and by their stronger development in certain places pass into veins, which are sometimes mere accumulations of these stringers in parallel juxtaposition, and at others form solid masses of dolomite several feet in thickness. In this respect they are similar in their behavior to quartz stringers, found under similar conditions in the same rocks. These dolomite veins have been formed generally in fissures striking with the schists, but in some cases they cross the strike. On the north-east end of Scotty Island a very good instance is seen of a dolomite vein, several inches in breadth, branching out from a large mass, apparently interbedded with the schists, and crossing the strike of the latter in a zig-zag course, filling an irregular transverse fissure. There is no reason to doubt but that the large deposits of dolomite of identical minearlogical characters and texture, which, from the size, have more the appearance of bedded masses, are also veins. When these larger deposits of yellowish dolomite occur in fissile hydromica-schists, the latter are characterized on either side of the main mass by small stringers of the same dolomite, often mixed with quartz, holding radiating bunches of tourmaline needles. These larger veins do not resemble stratified beds in being continuous across country for considerable distances. They seem, on the contrary, to be of very limited extent, those found, as sometimes happens, in approximately the same strike at widely separated intervals, being simply parallel segregations along a general line of veining.

General character.

These dolomites present in their weathered aspect a deep incrustation of ochre. In composition, they are often extremely silicious, the silica taking the form of a network of quartz stringers, which traverse the dolomite in all directions and stand out as prominent ridges upon its weathered surface. Cubes of pyrite and octahedra of magnetite are the only other minerals macroscopically observable in these dolomites. An analysis of a quartz-free specimen, given elsewhere, shows it to be nearly pure dolomite.

Green dolomite

Besides these yellowish dolomites, varieties of different color and texture occur, also as veins. An interesting green dolomite was found in fissile green schists on a small island between Pine Point and Heenan Point. A section of it (No. 9), under the microscope, is described as "consisting almost entirely of dolomite, whieh is in irregular grains, with beautiful cleavage lines running through them. In addition to these are little mosaics of quartz grains and considerable colourless hornblende. Some irregular patches of ocherous substance also occur, as if they were the remains of original pyrite crystals. This

rock, at first sight, resembles an eclogite, and appears to be composed largely of smaragdite. It is, however, almost all a carbonate."

A little to the north of the entrance to Ptarmigan Bay a narrow vein-like band, about two feet thick, was observed, of a beautiful, pink, soft, saccharoidal marble, in dark green schists. Pink dolomite.

On the north shore of Shoal Lake a calcareous rock of undetermined extent was observed and was supposed in the field to be a limestone; a more careful examination of it, however, shews that it can scarcely be so called. Analysis shews that it only contains 40 per cent. of carbonate of lime and magnesia. Its microscopic characters are as follows.—

"Section No. 40.—This rock consists of a ground-mass of quartz and an isotropic substance, with all the characteristics of Rosenbusch's 'felsitic ground-mass.' With this is mingled a quantity of calcite. Muscovite in shreds extends throughout it, and, besides, there are in it numerous crystals of rutile, some of which are twinned according to the ordinary law, giving rise to elbow-shaped particles. Aggregates of a dark-green mineral, slightly pleochroic, probably epidote, and a gray, cloudy substance complete the minerals in this rock.

"In order to place this rock in its proper classification, a much more thorough study of it is necessary than there is opportunity for. It seems to be a sort of calcareous metamorphic slate."

LIMITS OF AREA OF THE KEEWATIN (HURONIAN) ROCKS.—CONDITIONS OF CONTACT WITH SURROUNDING GRANITOID GNEISSES.

The Keewatin or so-called Huronian rocks, mapped on the sheet accompanying this report, occupies an area having the shape of a rhomboidal parallelogram, which presents the appearance of an almost isolated patch, surrounded by massive granitoid Laurentian gneisses* on every side. The area, as a whole, will be found when its geological structure comes to be considered, to have the characters of a sharply folded basin within which a great thickness of local deposition of peculiar rocks has taken place. The axis of folding of this basin is nowhere a straight line, but is flexuous. For purposes of description, however, it may be considered as approximately straight, and be said to intersect the meridian with a bearing of about N. 80° E. General outlines of Keewatin area.

* As stated on a previous page of this report (P. 50 CC.), the gneisses observed within the region described are all granitoid in character and often very coarse. They are, therefore, not strictly comparable with the more schistose and presumably newer Laurentian rocks which constitute the so-called Middle Laurentian, and which are found to rest upon granitoid gneisses like those above referred to, in other parts of Canada.—D.

To this axis of flexure the north and south limits of the area, i. e., the two greater sides of the rhomboid, are parallel, and it corresponds in a general way with the average strike of the schists which are embraced within it. The east and west limits of the area, or the shorter sides of the rhomboid, are not so uniform in direction as the north and south limits. They are formed to a large extent by the rather abruptly terminating folds of the Keewatin strata. It is an interesting fact that, while the greater portion of the strata strike E. N. E. and W. S. W., this is not the direction of the long, but of the short diagonal of the rhomboid, and that the long diagonal corresponds approximately with a line of intrusive granite masses running from W. N. W. to E. S. E.

Line of junction as shown on map.

It is desirable first to describe as accurately as possible the course of the boundary of this area, or the line of demarkation between its rocks and those of the Laurentian, in order that there may be a clear understanding as to what portion of the line, as mapped, is observed fact, and what portion of it is, as is unavoidable in nearly all geological field work, conjectural.

Junction at Rat Portage.

We may begin where the line is easiest of access, viz., at Hebe's Falls, near Rat Portage. Here, about a chain or so below the falls, at the lower end of the gorge through which the Lake of the Woods pours its waters into the Winnipeg River, the contact of the granitoid gneiss and Keewatin schists is seen, the dividing line having a strike of about N. 80° E. The lamination of the schists on one side of the line of contact and the foliation of the gneiss on the other, have a strike coincident in drection with it. The dip of both rocks is to the north at an angle of about 65° the schist passing beneath the gneiss. On the assumption that gneissic foliation is a proof of aqueous sedimentation, a cursory examination of the section showing the contact might lead an observer to decide that it was simply the conformable contact of two series of rock, of which the gneiss was superimposed upon the hornblende-schists. Another more careful glance at the conditions presented in the section would show him that there was no single, simple plane of contact between the two series, although the strike and dip were the same. Bands of gneiss are seen to be apparently interbedded with the schist, and on the supposition of a conformable contact there would seem to be alternating beds, making a transitional passage from one series to the other. Such was the explanation that presented itself to me when first I visited the section. A subsequent more critical scrutiny of the facts revealed in the section, however, rendered it impossible for me to consider these bands of gneiss mixed with the hornblende-schist as an alternating sequence of transitional beds. By the light of observations made on the contact of the two

Apparent interbedding.

series of rocks elsewhere, and a closer examination of their relations to each other here, it was found that a very different explanation of that relationship was not only possible, but highly probable. The bands of gneiss have rather the characters of igneous injections than beds. They are generally parallel with the lamination of the schist because the lines of lamination are the lines of weakness in the rock along which such injections would most easily find their way. The bands are short and their continuity interrupted. They either taper rapidly to a point or end abruptly upon the broken edge of a band of schist forming a kind of breccia, which, however, is more characteristically developed in similar exposures of the contact to be described further on.

Jointage.

The gneisses seem to have been in a plastic condition at a date subsequent to that at which the hornblende-schists had assumed a hard and brittle state. Both the gneiss and hornblende-schist are jointed but in different directions. To the north of the contact the gneiss presents a very well defined system of jointing, the planes of which are coincident with the planes of foliation the gneiss, *i.e.*, sloping to the north at high angles. In the hornblende-schists to the south of the contact, on the other hand, the jointing slopes to the south-west at low and rather inconstant angles. The gneiss is a distinctly foliated porphyroid rock, having a grey matrix of quartz and mica, in which are imbedded large, light, flesh-tinted crystals of orthoclase, which are often rounded in form, with a flowed structure, evidenced by the arrangement of the mica, conforming to their outline. The hornblende-schist is of dark-green to geeenish-black in color, evenly cleaved, and rather hard, but merging in places into softer varieties of lighter colour, and somewhat micaceous in composition.

Character of rocks at junction.

Line of junction traced westward.

The contact is seen on the east side of the gorge at the falls. From there the line runs beneath the bay of the river, which lies just to the west of the gorge, and the two rocks are seen a few yards apart on either side of the line of junction at the bottom of the bay, although the actual contact is concealed by a deposit of sand. From here the line may be traced, with comparative closeness, across Tunnel Island, without change in the dip or strike, to the second outlet of the lake below the Witch's Cauldron.

At Darlington Bay.

On the portage-path along the river at this point, the gneiss holds in places large and small angular fragments of the hornblende-schist. The line of junction crosses the river about eighteen or twenty chains to the north of the railway bridge, and, following the ridge which separates the waters of the lake from Darlington Bay, is next seen, over a mile to the west, near Keewatin station and still on the north side of the railway. A little further west the junction is again seen on the

shores of Darlington Bay, just below the water tank of the railway yard. The common strike of the gneiss and schist is here, as before, about N. 80° E., and the dip north. In a general way the planes of lamination of the schist and foliation of the gneiss are parallel, though here, as at the contact first described, there are unmistakable evidences that the contact is an igneous one, and that when there is a mixed alteration of gneiss and schist the former has been injected within the latter. This mixture of gneiss and schist, with occasional short broken bands and fragments of schist included within the gneiss, occur at intervals along the shore of Darlington Bay, to the railway bank which dams up the mouth of Mink Bay.

Mixture of gneiss and schist.

In some of these injected portions of the gneiss the mica is much less in quantity than usual, and the rock presents the character of a reddish mixture of quartz and feldspar with porphyritic crystals of the latter. In others the mica is quite visible, and gives the rock its characteristic gneissic structure, the foliation abutting upon the sharp or ragged edges of schist.

Darlington Bay to War-eagle Lake.

Half a mile farther west the gneiss just forms the edge of the south shore, and the line of contact has again a strike of N. 80° E. Beyond this in the line of junction crosses to the other side of the bay, still running in the same direction, and is again seen on both sides of the mouth of the northern extension of Darlington Bay, known as Middle Lake, the rocks having the same common dip and strike. The line of junction when next seen crosses the railway-track, about fifty chains westward of the trestle bridge at the bottom of Darlington Bay. From this point westward, the line of junction bends a little more to the south, for when next exposed, further on at the end of War-eagle Lake, the strike of the gneiss and schist is about N. 70° E., the dip as usual being to the north. War-eagle Lake has been hollowed out of the rocks along the line in question, for the line skirts the south shore of the lake with a strike varying from N. 60° E. to N. 70° E., the prominent points of the shore being tipped with gneiss, while the greater intervening portions expose northerly-dipping schists. The north side of the lake is all gneiss. From the west end of War-eagle Lake the line of junction bends against the north, and assuming a nearly east-and-west course, is next observed where intersected by the old cart-trail from the now abandoned Argyle mine to Deception. Between these points not only has the strike bent around considerably from its former course, but the plane of the dip has suffered a tortion, so that whereas it was at War-eagle Lake to the north, the schist passing under the gneiss, it is now to the south, and the actual relative position of the two formations is reversed. The structure is analagous to that of the surface of the whorl of a screw augur, if the edge of the spiral be regarded as corresponding to the

strike. The bend of the rocks is at the point mentioned, about S. 70° E. Dip south <70°.

Half a mile farther west the junction is again seen near to the east end of Rice Lake with the same strike of S. 70° E., and south dip common to both rocks. This reversal of the dip since it was last noticed on War-eagle Lake is associated in its course with an abnormal condition of the rocks, which is peculiarly interesting in its bearing upon the relationship of the hornblende-schists of the Keewatin to the granitoid gneiss. A glance at the map will show the disposition of the two kinds of rock at this junction in the line of contact we are now considering. The gneiss and schist appear to be wedged into each other in a way that is difficult to account for simply by folding. The schists that have been described as being in contact with the gneiss with a strike of S. 70° E. and southerly dip, on the Argyle mine road and at the end of Rice Lake, form a sharp tongue which seems to taper off rapidly at the west end of Rice Lake. *Junction at Rice Lake.*

This tongue of schist has a breadth of half a mile at the east end of Rice Lake, from where it is first mét with, on the portage path from Clear-water Bay to Rice Lake, to where it is again seen in contact with the gneiss at the north-east corner of that lake. The dip of the hornblende-schist across this breadth is continuously to the south, at angles varying from 70° to 65°, and the strike ranges from S. 85° E. on the south side to S. 70° E. on the north. At the west end of Rice Lake it has a breadth of about fifteen chains, strike S. 70° E., dip south. Beyond this it does not appear to continue much farther. To the south of this tongue of schist, the granitoid gneiss, under which it dips, has a breadth on the portage path of about half a mile, to the shores of Clear-water Bay, where it immediately again comes in contact with black hornblende-schists to the south. These hornblende schists are precisely similar to those on Rice Lake, but dip in the opposite direction, to the north, so that they also appear to run under the gneiss and constitute with the latter a basin in which the gneiss lies. The hornblende-schists found at the south end of the portage path and on the shores of Clear-water Bay to the east of it also form a rather abruptly ending tongue. As the convergence of the strike of these two enclosing tongues of schist would indicate, they merge into each other at no great distance to the east, for on the Argyle mine road the gneiss is not seen to extend that far east, the rocks in a fairly continuous series of exposures being all black hornblende-schists. Along this line of section the attitude of the hornblende-schists gradually changes from a northerly dip at the south, to a vertical position and then to a southerly dip as the contact with gneiss on the north is approached. This would again point to a synclinal structure, in the trough of which lies the gneiss crossed by the Rice Lake Portage. *Tongue of schist at Rice Lake.*

Difficulties in explaining stratigraphical relations.

The explanation is not, however, so simple as it would appear. If we were in a position to state definitely and without doubt that the granitoid gneiss is a sedimentary rock, then the facts which have been adduced point clearly to the explanation that the gneiss is now superimposed, and was originally superimposed, upon the hornblende-schist as a later formation. But we cannot assert that the granitoid gneiss is of sedimentary origin, and if we could, the explanation we would then be forced to adopt would involve us in the absurdity of the statement that one sedimentary series is at once above and below another, since this same granitoid gneiss is everywhere assumed to be stratigraphically inferior to the schist. There are other considerations which point to a totally different and more consistent explanation of the structure in question.

Abrupt termination of tongues of schist.

It will be seen by the map that the gneiss included between the two abruptly-ending tongues of inward-dipping schists occupies the shores of Clear-water Bay for a mile or more to the west of the portage path where it is first met with. It constitutes the rock in which Granite Lake lies and is continuous with the great area of Laurentian gneiss to the north. The whole breadth of the hornblende-schists coming from the east is very abruptly interrupted by this mass of gneiss, which is thus brought in contact with the next higher group of rocks the mica-schists and micaceous schist-agglomerates, which are exposed so extensively on the north shore of Clear-water Bay. The strike of the hornblende-schists, particularly that of the southern of the two tongues into which it bifurcates, appear to butt directly upon this interrupting mass of gneiss as upon an intrusion. The hornblende-schists would thus appear to have been at this place upheaved above the level that has escaped subsequent denudation, and their place occupied by the gneiss which has been squeezed up from below. Other facts also point to the probability of this being the true condition of things. The line of contact of the gneiss and schist, wherever it can be observed, is unmistakably an igneous one, the gneiss being in places injected through the schist in dykes and at others being a breccia in which the gneiss forms a matrix for the broken angular fragments of the schist.

Circumstances showing plasticity of gneiss subsequent to induration of Keewatin rocks

At the extreme west end of the portion of Clear-water Bay, which leads up to the portage, the hornblende-schists having been entirely removed, the gneiss is in contact with a mica-schist, which presents a feebly agglomeritic aspect in places, and breaks through it in irregular dyke-like injections, ranging in width from a few inches to several feet. The same thing is seen again near the portage, on the south side of the point of land that separates the waters of the bay from the creek that runs into it. Here the rocks are very much mixed, and the injected portions of the gneiss are more granitic in their texture and

of a redder color, the feldspar being the dominant constituent. Along the line of the contact to the south of Rice Lake, the planes of the foliation of the gneiss and of the lamination of the schist are quite parallel, and these appear to be an alternating transitional series of beds of gneiss and schist, but the gneiss is simply injected in the form of sheets along the lamination of the schist, and in places cuts them transversely. The gneiss also forms the matrix of a clearly-defined breccia, which can be traced for over a quarter of a mile to the north of the line of contact on the rounded surface of the bare, well-exposed rocks. The angular blocks vary considerably in size, but would probably have an average sectional area of about a couple of square feet. In some instances there is a flowed structure in the gneiss, conforming roughly with the outline of the included block. At other times the foliation abuts squarely upon its edge. These conditions admit of only one explanation, which, so far as it goes, seems to be true beyond dispute, viz : that the gneiss, let its foliated structure be explained as best it may, was in a plastic or viscid state at a time subsequent to the hornblende-rock having become hard, brittle, and capable of being broken off into the numerous fragments that are now found in the breccia along the line of contact. The existence of a distinctly foliated and even banded structure in the matrix of such a breccia demonstrates how altogether unnecessary it is to look for an explanation in a theory of aqueous sedimentation. The foliation has undoubtedly been developed in it at a period subsequent to its having been in a viscid or liquid condition, as not only these instances, but others, to be adduced farther on, prove.

Tongue of schist wedged apart by intrusive mass.

The bifurcation of the abruptly-ending belt of hornblende-schists, is such as might be looked for as a result of the upward protrusion of a great mass of molten rock. And although the schists in either spur of this bifurcation dip toward the central mass rather than away from it, as might be expected, this is not incompatible with the belief that the bifurcation is due to an igneous intrusion. The dipping of the schists in opposite directions towards each other does not necessarily imply a synclinal structure. From all that can be observed of the belt of hornblende-schists its breadth, as traversed by the Argyle mine road, from where it is in contact to the south with the agglomerate-schists to its junction with the gneiss on the north, is the natural thickness of the formations after correction has been made for the inclination of the rocks. This being the case, there is no true synclinal structure, only an apparent one, the nearly vertical schists having been wedged assunder by the rending force of the intrusion into two dividing tongues, the southern of which has been bent through an angle of more than 90°, so as to appear to dip northward at the plane of the present surface.

Junction on Clear-water Bay.

West of the point, on the shores of Clear-water Bay, where the granitoid gneiss is seen in contact with the micaceous schists, the line of junction, which here has a strike of about N. 70° E., curves around more to the south, and is seen on the south-west side of Granite Lake, with a strike of S. 70° E., the schists running around as if to embrace this mass of gneiss, much as they do around the Yellow Girl granite mass. The dip is N. < 75 on Granite Lake.

Line of junction further west.

Beyond this the character of the country is such that the line of junction has been traced out much less satisfactorily than the portion of it described. The line is next seen where it is crossed by the portage road from Indian Bay to High Lake, at a point about an eighth of a mile to the south of the falls by which the lake is drained. The rock in contact with the gneiss is a dark-green schistose hornblende-rock, and the gneiss itself is very granitoid in texture, a gneissic foliation being scarsely discernible in some portions of it, although in others it is sufficiently well marked. The strike is N. 80° E., and dip to the north. Four and a-half miles further west the junction crosses the Falcon River with a strike of N. 67° E., and northerly dip common to both rocks, although the actual contact is not exposed. The gneiss here is almost identical with that seen at Hebe's Falls, near Rat Portage, but perhaps a little coarser in texture.

West of the Falcon River the country sinks in level, and there is little or no access into it, so that it has been found impracticable to trace out farther in this direction the junction of the gneiss and schist.

Western termination of Keewatin rocks

The character of the western boundary of the area is inferred very largely from the conditions that are presented for examination on the shores from the Falcon River to the south end of Shoal Lake and at the mouth of the North-west Angle Inlet. The rocks on the west side of Shoal Lake are almost continuously exposed. From the junction of the gneiss and schists, on the Falcon River, there is a breadth across the strike of three miles of Keewatin rocks, chiefly schistose hornblendic, dioritic and diabasic rocks, with some bands of mica-schist, to where the gneiss is again found in contact with them to the south. This distance measures the breadth of a tongue of these rocks of the character of a folded trough, which, from the convergence of the strike, terminates at probably no great distance west of the end of Indian Bay in the great area of encircling gneiss to the west, which is well exposed on Snow-shoe and Rice Bays and on the shore of Shoal Lake.

The southern line of junction of this tongue of schists, with the gneiss, runs along the middle of the narrow peninsula that separates Indian and Snow-shoe Bays. Southward from the mouth of Snow-shoe Bay there is a continuous exposure of granitoid gneiss for a breadth of

three and a-half miles. To the north of this lies a green volcanic agglomerate rock, passing into a schistose hornblende-rock. To the south of the gneiss a group of schists, chiefly quartzose and micaceous and occasionally hornblendic in character, is crossed. The dips of both these rocks near the contact is south, and the strike is approximately south-west, but bends more and more to the north as the strata are crossed going north from the junction. The dip and strike of the rocks between this junction and the south end of the lake points to a synclinal structure, and as these rocks have not been found to cross the Dawson road to the south in the direction of their strike, it is conjectured, in the absence of proofs, due to the low swampy character of the country, that the strata terminate in some such fashion as is represented. The rock along the Dawson road, wherever it is possible to observe it, is a coarse gneiss.* On the east side of the south end of Shoal Lake a group of schists, similar to those in contact with the gneiss on the west side, is seen lying to the east of a gray granitoid gneiss. The dip of these rocks is away from the gneiss to the eastward. They are chiefly micaceous quartose schists of a gnessic structure, with often a considerable proportion of hornblende in some layers. A similar group of rocks is seen at the mouth of the North-west Angle Inlet. These also dip away from the gneiss, but towards the north so as to form a synclinal fold with those of Shoal Lake. The strike, like the dip, converges, so that the projections of that on Shoal Lake and on the shore of the inlet would meet at a point near the North-west Angle. The only rock seen in that neighborhood is that recorded by Dr. G. M. Dawson† as a "dark gneissic rock," which "holds apparently both hornblende and mica, which are arranged in thin and regular laminæ, and is nearly vertical with a strike of N. 70° E." (Mag.) and "compact greyish-black micaceous rock." Both of these rocks, I should judge from their description, belong to the group of rocks forming the synclinal trough, whose outer flanks are revealed on the east shore of Shoal Lake to the north and at the mouth of the North-west Angle Inlet to the south. This would locate the end of the trough somewhere to the west of the North-west Point, though from the nature of the country the actual course of the geological line I have endeavored to trace out, must always here be a matter of conjecture, and the mapping simply represent what is considered the most probable condition of the rocks, from the facts available for observation.

Exposures on Dawson Road.

Rocks near the North-west Angle.

* Dr. Bell reports that he "found Laurentian gneiss exposed at intervals along the road to Red River, for about thirty miles westward of the Government station at the North-west Angle." Report of Progress Geol. Survey of Canada, 1872-73, p. 104.

† Geology and Resources of the Forty-ninth Parallel, p. 25.

North-west Angle to Falcon Island. Between the mouth of the North-west Angle Inlet and the north end of Falcon Island the nature of the contact of the two series of rocks can only be partially examined, the greater space being occupied by the waters of the lake. So far as can be gathered from the intervening islands, there is much less distinctness and precision in the line of contact displayed here than anywhere else in the boundaries of the Keewatin area. Passing eastward, the mica- and hornblende-schists of the shore to the north of the inlet assume more and more an agglomerate structure and merge towards the gneiss into a quite feldspathic 'agglomorate gneiss,' which in turn, by a gradual obliteration of the agglomerate structure, seems to pass into granitoid gneiss, so as to render it extremely difficult to draw any sharp line of demarkation between them. On the north shore of Falcon Island and on the northern border of the Grande Presqu'île, however, the line of contact once more resumes that precision and definiteness of character, which marks it, to the west of Rat Portage, and becomes a simple, sharp line between a black hornblende-schist and a coarse-textured granitoid gneiss.

Junction at Falcon Island. The line of contact of the Keewatin and Laurentian, as it crosses Falcon Island, at no great distance from the north shore, forms a distinct curve, striking first to the east-north-east, then east, then bending rather sharply to the south-east. At the western extremity of the north end of Falcon Island, a considerable thickness of 'agglomerate gneiss' occupies a position between the hornblende-schist and the granitoid gneiss, although the contact of the latter with the agglomerate cannot be made out definitely. To the eastward this 'agglomerate gneiss' seems to thin out rapidly, leaving the hornblende-schist and granitoid gneiss in close contact. A sharp, pinched off infold of the hornblende-schists, produces a V-shaped digression to the southward in the line of junction, at the east side of the north end of Falcon Island. This sudden southward projection of the schists within the area of the gneiss, so suggestively indicative of a folding transverse in the direction of its action to that of the ordinary plications of the region, is almost directly opposite, (across the strike of the rocks,) to the abnormal break in the continuity of the line of junction noticed at Clear-water Bay, on the northern limits of the area. The apex of the V is naturally continued in the belt of black hornblende-schist that seems to lie in the bed of the Tug Channel, and forms the connecting link between the hornblende-schists of the neighborhood of French Portage and the area to the north, and these bands of schist, represented on the map as occupying the southern portion of Falcon Island, and skirting the southern shores of the Grande Presqu'île.

V-shaped fold.

The apex of the V is two and three-quarter miles south of French Portage, and its return sweep to the north passes to the east of that point only a few dozen yards, the contact being seen on the ridge between the portage and the marsh to the east of it.

Whenever the contact of the schist and gneiss can be observed along the outline of this V, there is the usual parallelism between the planes of lamination of the schist and those of the foliation of the gneiss. The strata here have been subjected to unusually violent tortions, and at distances not great from the actual contact, the strikes of the two rocks are sometimes discordant, but they invariably curve around into parallelism, whenever the actual contact is exposed. Coupled with this parallelism of strike and dip, however, are also the phenomena of the injection of the gneiss within the schist. This is very characteristically seen in the patch of schist that outcrops on the west shore of the Tug Channel, a little over a mile and a-half to the south of the apex of the V. Contorted rocks

Beyond French Portage the line of junction bends round so as to have more of an easterly trend, and within the next six miles there are three excellent sections showing the contact, afforded by Beaver Inlet, Astron Bay and Maud Lake, long, narrow sheets of water extending southward from the main body of the lake into the Grande Presqu'île. The line crosses these bodies of water close to their entrance into the main lake. The strike of schist and gneiss at French Portage is about N. 45° E.; at the mouth of Beaver Inlet it is N. 65° E.; at the mouth of Astron Bay it is N. 70° E.; and at the foot of the little cascade by which Maud Lake is emptied it is N. 75° E., the dip throughout being to the north at angles from 60° to 65° and 70°, so that the gneiss passes beneath the schist. North side of Grande Presq'île.

At the mouths of Beaver Inlet and Astron Bay the contact of the two rocks is clearly exposed, and dykes of the gneiss are seen penetrating the schist parallel, for the most part, to its lamination. At the outlet of Maud Lake the contact is not observable, although the two rocks are seen a few yards apart from each other. All the rest of the shores of Beaver Inlet, Astron Bay and Maud Lake, to the southward of the contact, are composed of reddish, granitoid gneisses. Junction along west shore of White-fish Bay

The next point to the east where the line of contact is intersected is at the bottom of the most north-westerly arm of White-fish Bay, five miles west of Rendezvous Point, where the common strike is S. 55° E. and the dip N. $<$ 75°. There are here to the north of the contact, sheets of gneiss parallel to the lamination of the schists, which are probably injected from the main mass of gneiss as has been found to be the case elsewhere. Beyond this the line of junction assumes an east-south-easterly trend and is next exposed on the shore of White-fish Bay about

a mile and a-half south-west of Rendezvous Point. Thence it crosses the small islands lying in the White-fish Bay Passage, known as the East and West Pointers, with a more easterly strike, the junction of schist and gneiss being again exposed in a little bay on the extremity of Long Point, at a place almost due east of the exposure to the south-west of Rendezvous Point. To the south-eastward of this the strike of the line of contact and the trend of the shore of White-fish Bay are for a long distance practically coincident, as will be gathered from a glance at the map. From the extremity of Long Point the strike of the rocks carries the line of junction inland for some distance, but it soon curves rapidly to the southward. On the north side of Long Bay its course is seen to be interrupted by a mass of red granite evidently intrusive through both gneiss and schist, but on the south side of the bay the gneiss and schist are again seen in contact, with a common strike of S. 30° E., and a north-easterly dip at high angles. About a mile farther on the line is again exposed on the south-west side of Long Point with the same trend of S. 30° E. and northerly dip of the strata.

Junction along east shore of White-fish Bay

From this point the line of junction runs south-eastward across Fire Island, the north side of which is occupied by schist and the south side by gneiss. It is next seen skirting the east shore of White-fish Bay, the gneiss tipping the prominent headlands such as Return Point, White Point, Cat Point and Paddle Point, while the intervening stretches of shore expose black or dark-green hornblendic schistose rocks with occasional bands of mica-schist. The strike at Fire Island is about S. 30° E., but at Sioux Point and towards Return Point it curves around to S. 40° E. and then to S. 50° E., the dip throughout remaining for the most part to the north-east or vertical; though in places reversed. The line of junction all along this north and north-east shore of White-fish Bay is a brecciated one. Wherever a section of the rocks showing the contact is observable the gneiss is seen to have been injected or protruded within the schists, and to contain irregular fragments of the latter at varying distances from the contact of the two rocks, although their planes of lamination present a well-marked parallelism on either side of that contact. Along the shore which cuts the strike of the rocks to the south-west of Rendezvous Point numerous dykes of gneiss cut the schists, both as apparently evenly intercalated beds, and as irregular and intrusive masses.

Details of junction, mouth of White-fish Bay.

As the great gneissic area to the south is approached these become more numerous. The junction itself is exposed on this shore on the face of a low cliff presenting the appearance figured in the annexed diagram, there being apparently no sharply defined line of contact, but a transitional series of layers of alternate gneiss and schist. These bed-

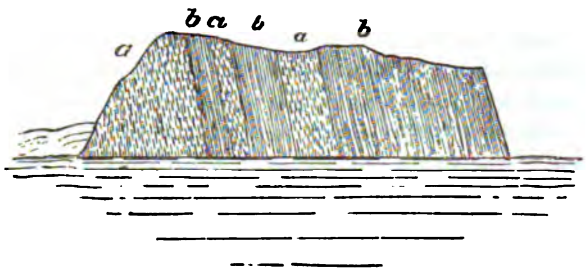


Fig. 7.— *a*. Granitoid gneiss. *b*. Hornblende-schist. The two rocks apparently interbedded as a transitional alteration, but the gneiss in reality intruded within the schists. Scale 1 inch = 20 feet.

like sheets of gneiss within the schist, however, are injected as may be gathered from an examination of the same line of junction on the islands a little to the east. The accompanying diagram, (Fig. 8,) illustrates the junction on an island known as the West Pointer, near the mouth of the White-fish Bay.

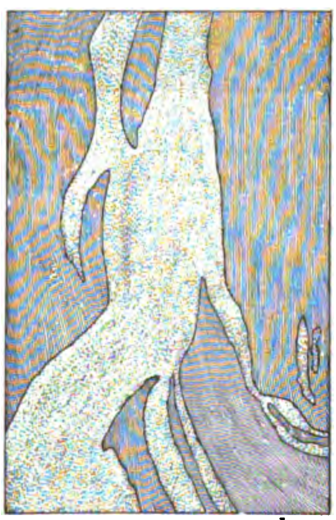
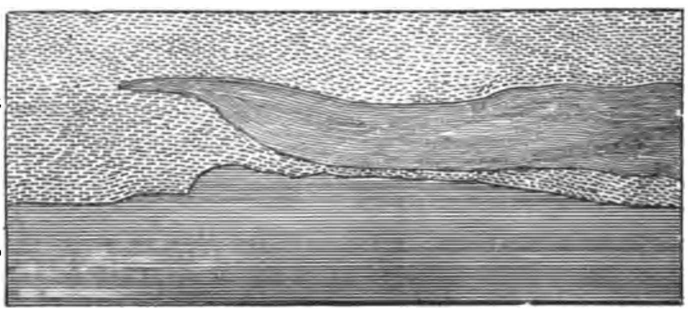


Fig. 8.—Gneiss injected within hornblende-schists in immediate vicinity of contact of the two formations. *a*. Gneiss, *b*. Hornblende-schist. Scale 1 inch = 5 feet.

The northern portion of the island is occupied by greenish-black hornblende-schists, and the southern by coarse-textured gneiss. About the middle of the island the irregular intrusion of gneiss, shown in the

figure, breaks through the hornblende-schists. The intruded rock resembles closely the regular gneiss to the south of the contact, and its foliated character is quite as well defined. The irregular nature of the fissure through which the gneiss has been injected is such that it cuts across the schists at some places and runs with the strike in others. The foliation of the contained gneiss is approximately parallel to the walls of the fissure. In one place this foliation and the general run of the dyke have a common strike of N. 45° W., while the schists which abut sharply on the dyke, have a strike due east. The intrusion is beyond question identical with the great mass of granitoid gneiss to the south, and the conditions of its occurrence afford a striking proof

Evidence of plasticity of gneiss.



Section illustrating alternations o gneiss and schist.

Fig. 9.—Contact of gneiss and hornblende-schist. Island in the White-fish Bay Passage. *a.* Gneiss. *b.* Hornblende-schist. Scale, 1 inch = 4 feet.

of the plastic condition in which these rocks must once have been either as an original state, or as induced at the time of folding The belief that this intrusion constitutes a part of the granitoid gneiss is borne out, not only by the similarity of the rocks, but also by the nature of the contact a few yards to the south. An instance of the appearance presented along this contact is shown in Fig. 9, in which the gneiss, which behaves as an injection, is in actual continuity with the great area of gneiss to the south of the contact.

On the shore of White-fish Bay, at Return Point, a little below the Sioux Narrows, an excellent section is exposed shewing the mixed character of the contact of the gneiss and schist. On the north side of the point is a great thickness of hornblende-schists, while to the south lies the great area of the White-fish Bay gneisses. The intervening or prominent portion of the point is occupied by the following alternation of bands of gneiss and schist, the strike of the rocks being S. 50° E., and the dip either vertical or at very high angles to the south:—

1. Gneiss	1 foot 7 inches.				
2. Hornblende-schist	54 feet.				
3. Gneiss	11	"			
4. Hornblende-schist	60	"			
5. Gneiss	3	"	8	"	
6. Hornblene-schist	31	"			
7. Gneiss	1		8	"	
8. Hornblende-schist	11	"			
9. Gneiss	20	"			
10. Horblende-schist	22	"	7	"	
11. Gneiss	0		8	"	
12. Hornblende-schist	58	"			
13. Gneiss	4		4	"	
14. Hornblende-schist	6	"			
15. Gneiss	0	"	6	"	
16. Hornblende-schist	32	"			
17. Gneiss	12	"	2	"	
18. Hornblende-schist	13	"			
19. Gneiss	1	"	8	"	
20. Hornblende-schist	4	"			
21. Gneiss	3	"			
22. Hornblende-schist	1	"	3	"	
23. Gneiss	1	"	6	"	
24. Hornblende-schist	5	"			
25. Gneiss	0	"	4	"	
26. Hornblende-schist	0	"	8	"	
27. Gneiss	1	"			
28. Hornblende-schist	1	"			
29. Gneiss	2	"	8	"	
30. Hornblende-schist	5	"			
31. Gneiss	100	"			
32. Hornblende-schist	12	"			
33. Mixed gneiss and schist	20	"			

Gneiss indefinite thickness.

These bands of gneiss alternating with the schist are for the most part regular and bed-like in their characters, but their true nature as injected sheets or dykes is sufficiently revealed.

That marked No. 9 is less regular than the others and penetrates the containing schist in irregular tongues. No. 21 is also very irregular and includes fragments of the schist walls. No. 23 is quite irregular in its thickness and does not resemble an interstratified bed. No. 29, though quite distinctly foliated, penetrates the schist and holds within it slender, wedge-shaped bands of schist. The last twenty feet of this alternating series of bands is very brecciated in its character, the gneiss penetrating the schist in every direction and holding angular blocks of it. Fig. 10 shows a vertical section of a broken and ragged edge of hornblende-schist that has been enclosed by the gneiss.

Ragged edges of hornblende-schist.

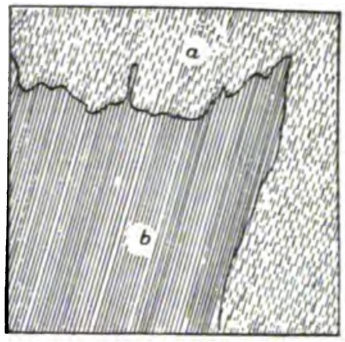


Fig. 10.—Vertical section showing angular corner of hornblende-schist included within gneiss, *a*. Gneiss, *b*. Hornblende-schist. Scale 1 inch = 4 feet.

Irregular intrusion of gneissic rock.

Fig. 11.—Horizontal section showing gneiss injected within hornblende-schist on shore of White-fish Bay south of Sioux Narrows.
a. Gneiss.
b. Hornblende-schist.
c. Unexposed.
Scale, 1 inch = 2 feet.

Fig. 11 shows the ground plan or horizontal section of another instance of the irregular intrusion of well foliated gneiss within the schists. The schists have a uniform strike of S. 50° E.,and often abut obliquely upon the walls of the gneiss, to which the foliation of the latter is for the most part parallel. To the south-east of Return Point the strata bend around to S. 20° E., and the dip is decidedly to the north-east, being on Cat Point at as low an angle as 45°. After crossing the mouth of Snake Bay, the line of junction is next exposed on Paddle Point, with a strike of S. 25° E., and again it can be approximately located in the bay just to the east of Turtle Point. The next three miles of its course can be fairly traced by the sections presented in the inlets of Snake Bay, although the grassy nature of the shores at these points renders it difficult in some cases to observe the actual contact. The line as mapped, however, is very nearly exact, the rocks being exposed at no great distance on either side of it.

Junction between Return Point and Sebaskong Bay.

Beyond the bottom of Snake Bay the line of junction runs through a rough bush country, and has not been traced in the interval between this and where it crops out on Last Point. In 1884, Mr. J. W. Tyrrell examined and made a log-survey of the west side of Crow Lake, and found the rocks throughout to be schists, and chiefly hornblendic in character, and this fact, coupled with the strike of the rocks as far as it has been observed on White-fish Bay, makes it altogether probable that the line of contact of gneiss and schist, which Messrs. Barlow and Smith have traced from Return Point across Snake Bay, is the same as that which comes out on Last Point, the strike of the rocks having curved around in the direction indicated by the coast-line of the bay. The line of junction crosses the narrows of White-fish Bay at Last Point, the rocks having a strike of about due west and a southerly dip. Thence it runs westward, and appears next on the Lake of the Woods side of the Grande Presqu'îsle, at the bottom of Burrow Bay. Between this point and Sebaskong Bay, a few miles to the south, the hornblende-schists are much mixed with intrusive gneisses, and the band which composes them appears to bifurcate and thin out rapidly towards the extremity of Rabbit Point, the rocks retaining their north-east or east-north-east strike, and the dip being prevailingly to the north-west at high angles.

South side of Grande Presq'île.

The southern border of this tapering band of hornblende-schists skirts the north shore of Sabaskong Bay, often appearing on the off-lying islands, which, however, are for the most part composed of gneiss of a coarse, granitoid character. Westward of Rabbit Point the hornblende-schists appear to thin out completely for an interval, and are not seen again, save in small fragmentary patches on the island, till Stairway Point is reached, on the shore north of Split Rock Island. Here we come upon the thin end of an immense wedge, or rather lens-shaped area of hornblende-schists, which occupies the southern portion of the Grande Presqu'îsle and the off-lying islands for a distance of about ten miles, or nearly to the mouth of Sabascosing Bay. At Stairway Point the schists are inclined at low angles, 30° to 35°, and are seen to be interbedded with sheets of gneiss, which, however, occasionally breaks through the hornblende-schists transversely in dykes, thus indicating its intrusive origin, as does also the wedge-like characters of the more stratiform portions of the gneiss. The strike here is about N. 10° E., and the dip north-west. Westward, along the shores of the channel north of Split Rock Island, the strike gradually bends around to east and west, and in the vicinity of Sand Point to west-north-west. In the transverse section afforded by the channel between the main shore north of Sand Point and North Island, this band of hornblende-schists is seen to attain its maximum breadth of two miles. On

North Island the schist is frequently characterized by the presence of white feldspar, indicating a passage to dioritic schist. The band occupies the northern portion of North Island, and the whole of Fish, Fire-bag, and Rough Islands. A more westerly exposure is that of a small island about a mile and a-quarter south of Starting Point. On the southern portion of North Island a band of gray gneiss traverses the island from east to west, and skirts the shore of the channel to the east of Sand Point, dividing the main band of hornblende-schists from another smaller and apparently less regular band which occupies the south end of North Island and the greater portion of Rubber Island.

To the west and north-west of Starting Point this band finds its continuation in the hornblende-schists of Poplar Island, Dagger Island, and the islands between the latter and the mouth of Sabascosing Bay. These are in turn the south-west continuation of the pinched-in fold of hornblende-schists which extends southward along the line of the Tug Channel, from the main area of the Keewatin rocks in the vicinity of French Portage.

General outline of border round the Grande Presq'île. It will thus be seen that the line of contact of hornblende-schist and granitoid gneiss has been traced from French Portage in an extensive ellipse, skirting the north shore of the Grande Presqu'île, the north-east and south sides of White-fish Bay, and the south and south-west shores of the Grande Presqu'île again, back to the starting point at French Portage. This encircling area, which is practically continuous, is constituted on the north by the main area of the Keewatin rocks, while on the south it is of the character of a narrow band, as if it were the remains of the folded outermost margin of the basin in which the Keewatin rocks were originally deposited. This encircling zone of schists embraces within it a great central area of coarse, granitoid gneisses, well displayed on the shores and islands of White-fish Bay, on the shores of the Grande Presqu'île, and on the inlets and lakes which extend into its interior. The whole structure is that of an immense anticlinal dome of upheaved gneiss, upon the flanks of which are arranged, concentrically to its outlines, the hornblende-schists of the higher series.

Spur of hornblende-schists. The infolded band of hornblende-schists which branches off transversely from the main area to the south of French Portage and extends up the Tug Channel, crosses the channel obliquely in its southward course from the east side to the west, near the south end of Falcon Island. At the latter place the band divides into two spurs, one of which bends sharply around to the south-east, and finds its continuation in the same schists exposed in the neighborhood of Dagger Island, while the other spur extends westward across the south end of Falcon Island. The western extension of this band of hornblende-schists has

a breadth of over a mile and a-half, but ends very abruptly to the west on account of the sharp upheaval of the lower rocks in that direction and consequent on the irruption of large masses of granite. The southern margin of the hornblende-schists, *i. e.*, the line of its contact with the granitoid gneisses, crosses the north end of Oak Island and the middle of Brick Island. On the north-east end of Oak Island denudation has revealed the actual crest of the anticlinal folds of the strata, which thus appear like so many huge sheets of rounded boiler plate. The crest or axis of these folds dips to the east at an angle of 15°, a fact which may be taken as a strong proof that the upheaval which attended the irruption of the granites to the westward took place at a period later than that at which the schists were folded along the east-and-west axis. This well displayed inclination of the crests of folds is a remarkably good illustration of a system of cross folding which is more or less obscurely discernible throughout the region and which has been remarked upon by Dr. G. M. Dawson.* The infold of the Tug Channel is of course another notable instance of the effects of this cross folding, although this appears to have been contemporaneous with the ordinary longitudinal folding rather than due to a later local upheaval. System of cross folding.

The area of hornblende-schists which thus occupies the south end of Falcon Island and the northern portions of Oak and Birch Islands, has infolded with it a considerable volume of a higher group of mica-schists and evenly laminated fine-grained grey gneiss, merging into micaceous or gneissic agglomerates in places. On either side of Sturgeon Channel these mica-schists are well exposed, but are not seen to the west of the granite which occupies Cyclone Island. To the south-east they are represented by the band of mica-schists which crosses Poplar Island about its middle. On either side of Deep Water Bay, a group of more or less gneissic schists, merging on the west side into agglomerates, and confined to the north and south by hornblende-schists, is observed. These are seen to cross Gardner's Island in bands alternating with bands of hornblende-schist. East-south-east of Birch Island the hornblende-schist is traceable across a string of islands to Bay Island where the schists curve around from an east-and-west strike to a south-east and then a south-west strike, the shape of the island conforming very closely to the curved strike of the rocks. This bending of the strike of the schists here seems to be due to an irruption of granite, the greater portion of which is probably concealed by the waters of the lake, but a portion of which is exposed on the south end of Poplar Island. Rocks of Falcon, Oak and Birch Islands, etc.

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*Geology and Resources of the Forty-ninth Parallel, p. 48.

On Windigo Island a band of black hornblende-schists runs through the island for nearly its whole length with a strike of 45°. It appears to have the character of an infold within the gneiss, and tapers off to a point towards the south end of the island. Other smaller bands and patches of hornblende-schist of a similar included or infolded character are not infrequent in the gneiss of this neighborhood.

Line of junction traced eastward from Rat Portage. If we now return to our starting point, Hebe's Falls, the remaining portion of the outline of the area, so far as it has been actually traced, will be indicated going from that point eastward. It was found there that the schists and gneiss had a common strike of N. 80° E., and that the former dipped under the latter to the north. About two miles to the east-north-east the contact is again seen on the little lake that lies to the north-east of the town of Rat Portage, the rocks having the same strike and dip. Beyond this the line curves more to the north and is next observed where it crosses the narrows of Black Sturgeon Lake with a strike of N. 35° E. In the interval between this and the last exposure not only has the strike bent considerably from what has hitherto been its general trend, but the rocks have undergone such a tortion that the dip is here to the south-east, the schists occupying their normal relation of superposition to the gneiss. The breadth across the strike of these hornblende-schists at the narrows of Black Sturgeon Lake is only one and a-quarter miles. The strike at the eastern side of the belt is N. 26° E. and the dip west at high angles. This convergence of both dip and strike points to the structure of a synclinal trough, pinched in within the gneiss and tapering to the north. The extension of this belt of schists to the north of Black Sturgeon Lake is not a matter of observation, since the country in that direction is partially inaccessible. To the south the belt widens out very considerably and has a breadth along the line of the Canadian Pacific railway of four miles, or, in a direction at right angles to the strike, of two and three-quarter miles.

Tongues of Keewatin rocks A mile farther east along the railway, from the base of this larger tongue of hornblendic schists, which runs north beyond Black Sturgeon Lake, is the tip of a smaller one, parallel in direction to the first, extending from the main area. The eastern side of this tongue of Keewatin rocks runs southward to the east of Hilly Lake, and the line of junction of schist and gneiss sweeping around its south end at a distance of a quarter of a mile from it, trends again to the south-east to a point on the Pine Portage and Rossland waggon road, one and a-half miles north of the office of the Pine Portage mine. Here it bends again sharply to the south, and can be traced approximately as mapped through the bush to where it passes the shaft of the Pine Portage mine about 150 feet to the east of it. South of this it can be followed

to the small lake, nearly due south of the shaft, which lies between the two series of rocks, and thence it runs south-east to cross the Long Lake Creek about fifteen chains south of the outlet of the lake.

Storm Bay to Route Bay.

It is next seen crossing the bottom of Storm Bay and then that of Route Bay. Inland the line is seen next on Hollow Lake, the north end of which is about two miles east of the Winnipeg Consolidated mine. The portion of the line of contact that has just been indicated as running in a sinuous course from the railway near Hilly Lake to the east of Big-stone Bay, is essentially a line of breccia, in which the gneiss forms the paste for broken fragments of schist. Numerous irregularly ramifying dykes of gneiss also penetrate the schist. This brecciated condition of the rocks is more characteristically developed to the south-eastward. It is observable where both the Pine Portage and the wagon road to Rossland cross the line of junction. The rock to the east of the line of junction, in the neighborhood of the Pine Portage mine, is perfectly granitoid in structure and presents the character of mass of intrusive granite. Traced easterly, however, along the line of its contact with the hornblende-schist it gradually assumes a more and more distinct gneissic structure, while at the same time its characters as an igneous intrusion along the contact become more distinctly marked. At the bottom of Storm Bay the rock is quite gneissic and yet it sends off dykes, whose foliation is not less distinct than that of the main mass, into the schist, and is in places thickly studded with angular blocks of the latter. The same thing is repeated and is well displayed at the bottom of Route Bay, where in places the gneissic foliation of the matrix of the breccia is distinctly seen to curve or flow around the angles of the included blocks. This breccia extends for considerable distances to the north-west of the line which defines the extent of the hornblende-schist as an unbroken mass.

Blind-fold Lake to Black River.

A section across the bare, burnt country, from the south arm of Blind-fold Lake to Hollow Lake, through which the line of junction runs, shows the breccia extending for half-a-mile from that line. Two miles and a-half to the south-east the line of junction it is again observed on a small lake east of the base of Pipe-stone Point. Beyond this, owing to the inaccessible character of the country, the line has not been actually investigated for a considerable distance. From the sections which it has been possible to make north and south from the end of Witch Bay, however, and from the rocks exposed on the Adams River, and those on the Black River to where the contact of schist and gneiss is again seen, there can be little doubt that the general disposition of the rocks is approximately such as is represented on the map, particularly as the country to the east and north-east is known to be all gneiss.

Between Black River and Long Bay.

On the Black River, at a point about four and a-half miles from its mouth, the green schist and granitoid gneiss are seen in contact, with a strike of about S. 25° E. and vertical dip. Between this and the inlet of Long Bay, where the contact is again observed, there is evidently an S shaped curve in the strike of the schists. Where the contact is met with on the shores of the inlet of Long Bay, the strike is S. 70° E. and the dip to the north, so that the schists pass under the gneiss. From the mouth of this inlet eastward for a couple of miles an area of gneissic agglomerate occupies a position between the schist and the gneiss. The line of junction of schist and gneiss is seen again at the extremity of Long Bay with a strike of S. 40° E. and southerly dip of the rocks, just before it passes beyond the limits of the area defined by the accompanying sheet. The contact here is distinctly brecciated and the matrix may be observed to pass from a massive granite, or a miceo-granite with porphyritic quartz and feldspar, through schistose varieties to a well foliated gneiss.

Relations of Keewatin to underlying gneisses.

Having now sketched somewhat in detail the outline of this Lake of the Woods area of Keewatin rocks and explained the conditions found to obtain along the contact with the granitoid gneiss, by which the Laurentian is here represented, I shall proceed to consider briefly to what extent we are able to define the stratigraphical relations of the series. The series has hitherto been, at least provisionally, correlated with Logan's typical Huronian. Believing, as previously stated, that such a correlation is not justifiable upon evidence at present available, the relations of this series to the adjacent granitoid gneisses will here be considered quite independently of what may be the relations of the typical Huronian to the Laurentian. Any conclusions that may be set forth therefore have no necessary connection with the disputed question of the relation of Huronian to Laurentian; and if the same conditions are not also true of the typical Huronian, the difference will only constitute another strong reason for the belief in the geological disparity of the Keewatin and Huronian.

Conditions at Rat Portage.

Apart from the differences among geologists as to the relations of the Huronian and Laurentian, there are also differences of opinion, not very strongly expressed, as to the nature of the relation which exists between the specific series of rocks here spoken of as the Keewatin, and the Laurentian. Dr. Bell states that the two series have the same strike and dip at the contact near Rat Portage, and the contact is alluded to as conformable.* Dr. G. M. Dawson adduces the same facts as to the appearance of conformity at the same place of

* Geological Survey of Canada, Report of Progress, 1872-73, p. 104.

contact, but conjectures that the gneiss and schist have been brought into juxtaposition by a fault.* Dr. Selwyn and other geologists who have examined this contact have inclined to the opinion that the two series are in conformable relation to each other.

These opinions as to the conformity or unconformity of the two series have not, however, been based upon the examination of any extensive portion of the line of contact. A summary of the evidence bearing on this question, afforded by an examination of a great number of exposures showing the contact around the whole periphery of the area, will be of service in aiding towards the general acceptation of a definite conclusion upon the matter. It may be well to premise that the evidence points more ways than one, and that it is only by a critical investigation of it that we can arrive at the real facts of the case.

Supposed conformable junction of the two series.

The belief that the two series are conformable finds its chief support in the parallelism of the foliation of the gneiss and the lamination or bedding of the schists. This involves, of course, the assumption that the foliation of the gneiss is either actually the remaining traces of original sedimentation, or that the planes of the former are coincident with the now obliterated planes of the latter; and if the assumption is to hold it will be very difficult indeed to deny the conformity of the two series. It is, however, highly improbable that the foliation of the gneiss has anything to do with an original sedimentation. Numerous instances have been cited in the preceding pages of the brecciated condition of the contact of the gneiss and schist. Gneissic foliation is seen to have been developed in a rock which was once in so liquid or viscid a condition as to permit the passage through it of angular blocks of schist to considerable distances from the source from which they were detached. A rock to have been in a state so yielding must necessarily have had all traces of an original sedimentation, if any such existed, obliterated. Furthermore, the existence of a well-marked foliated structure in dykes which have been injected within the schist, both parallel and transverse to its lamination, and which are sometimes traceable in unbroken continuity with the main area of the gneiss, proves conclusively that such foliation was induced in the rock subsequent to its having been soft enough to have undergone injection, and therefore, to have had any traces of sedimentation destroyed.

Foliation does not indicate bedding.

In other words, the foliation of the granitoid gneisses is developed in rocks once viscid or plastic, quite independently of any arrangement due to sedimentation they may or may not have possessed. This conclusion does not necessarily imply that the gneiss and schist may not

*Geology and Resources of the Forty-ninth Parallel, p. 46.

have been originally sedimentary and conformable. As a matter of opinion, I incline to the belief that the granitoid gneisses of the Laurentian were never aqueous sediments, but the conclusion which the facts adduced lead to is independent of either the origin of the rocks or their original stratigraphical relations. It simply proves that the foliation is no indication of sedimentation, and that so far as the question of conformity depends upon it there is nothing to go by. The schists may have followed the granitoid gneiss in close sequence, and been laid upon it quite conformably, if its sedimentary origin be granted, but there is nothing in the foliation of the gneiss to lend support to such a supposition. Thus the main ground upon which the contention for the conformity of the two series is based is shown to be exceedingly weak.

Circumstances tending to show an unconformity. On the other hand, it is difficult to find direct stratigraphical evidence of a marked unconformity, for the same reason that there are no reliable evidences of sedimentary stratification in the gneisses. There are, however, some considerations which point to a very distinct historical and natural break between the two series. The most evident of these is the sharp contrast in their lithological characters. The granitoid gneisses are essentially acidic rocks, while in the Keewatin the basic minerals predominate. No classification could require a more sharply defined line between two natural kinds of things than that which nature has drawn been the light-colored, coarse-textured, massive, highly feldspathic, acidic gneisses on the one hand, and the dark-green or black, fine-textured, schistose, basic, hornblendic rocks usually in contact with it on the other. The sharpness of the contrast is in itself eminently suggestive of so radical a change in the conditions of formation as to be tantamount to an unconformable break.

Again the Keewatin area presents, as has been already stated, the characters of a folded trough in which had rapidly accumulated a great local thickness of mixed volcanic rocks and aqueous sediments. The conception of such a trough or basin, which is forced upon one in a consideration of the geological structure of the region implies an unconformity. The fact that we find in the Keewatin series the first undoubted evidences for this region of aqueous sedimentation and also of volcanic action, while in the underlying Laurentian gneiss of the region we find evidence of neither, more than suggests that the Keewatin series had a totally different kind of origin from that of the gneisses, and must, therefore, be in unconformable relation to them.

Absence of fragments of underlying series. There can be little doubt that in the volcanic origin of the basal member of the Keewatin series we must seek the explanation of the fact that there is found in it no detritus of the underlying rocks. The deposition of the volcanic material, from which have been derived by

processes of urilization and analagous changes, the altered traps and hornblende-schists, seems to have preceded the first discernable influence of water as a stratifying agency.

The Granites.

Structural importance of granite masses. The granitic intrusions of the area of the Lake of the Woods may be grouped under ten main centres of occurrence or distribution, with a number of bosses of minor importance, which appear to be independent of these. The existence of these granitic masses is a factor of prime importance in the consideration of the stratigraphy, and it is therefore convenient to speak of them in an order which the structure of the region indicates as the natural one from this point of view. Beginning at the eastern portion of the chief curvilinear axis of folding or upheaval of the trough, that order is as follows:—

Enumeration.

(1.) The Yellow Girl Granite Mass, with its ramifications to the N. W. and S. W.
(2.) The Deadman Portage Granitic area, comprising the Carl Bay and Portage Bay masses, with probable ramifications at Crow Rock Channel to the N. E., and on the shore of Shoal Lake, to the S. W.
(3.) The Canoe Lake Granite Mass, with its subordinate masses.
(4.) The Indian Bay Granite Mass.
(5.) The Big Narrows Island Granite Mass.
(6.) The Granite area, North-west Angle, comprising numerous sporadic masses of granite of small extent.
(7.) The Sioux Narrows Granite area.
(8.) The Poplar Bay Granite boss.
(9.) The Many Island boss (Gneissic in structure).
(10.) The Split Rock Island Granite area.

The Yellow Girl Granite Mass.

Relation to enclosing rocks. The Yellow Girl granite, in the main mass, occupies an approximately circular area of about four miles diameter in the central portion of the Eastern Peninsula, with a club-shaped extension running out from its south-western edge to the shores of the lake at Yellow Girl Point. In my first reconnaisance of the shores of this peninsula, while the details of the topography were being worked out, I observed that the strike of the rocks was everywhere conformable to the three directions which determine its general contour, or more simply, that the strike seemed to follow the shore-line, and run around the peninsula. This arrangement of the rocks naturally suggested a centre of upheaval about which the strata, exposed on the shores of the peninsula, had

been caused to assume a concentric attitude. The granite exposed at Yellow Girl Point, which was all that was then known, seemed only to interrupt the continuity of the rocks, and did not in itself afford an explanation of the stratigraphical conditions presented. Its presence, however, taken together with the very suggestive arrangement of the rocks, led me to conjecture the existence of a much more extensive inland mass of intrusive granite, of which that at Yellow Girl was only a ramification. On proceeding, the following season, to test the truth of this hypothesis, I was pleased to find it verified in the most satisfactory manner. Bear Bay was discovered, which, from its extremely narrow mouth, had been overlooked the previous year, and by the access it afforded me into the peninsula from the south, revealed the distribution of the granite, as mapped on the accompanying sheet. When water did not afford a means of approach, excursions through the bush from the south, west and north sides of the peninsula, with the object of locating the limits of this hypothetical granite mass were in every case attended with success, and the fact established that the larger central portion of the peninsula was in reality occupied by a great upheaval of granite, which had exerted a profound influence upon the structure of the strata through which it protruded. Towards the west end of Yellow Girl Bay the granite was found to come within a quarter of a mile of the south shore of the peninsula and its continuous extension from its contact here with the schists, was traced northward up the bed of a small creek, and north-westward over the bare rocky *brulé*, well towards its central portions. From the east side, a brook, falling into the lake a couple of miles north of Yellow Girl Point, was followed up to the edge of the granite, and sufficiently far beyond to establish its identity with the mass observed at the points accessible from the south side. On the north side of the peninsula a continuous section of the strata was traced through the bush for a mile and a-half from the east end of Witch Bay, to the contact of what is apparently their lowest exposed member with the same granite mass, which is well shown for a considerable distance south of the contact. On the east the confines of the granite are determined only by inference. The traverse of the Adams river, with its exposures of a large development of mica-schist, constitutes a known limit beyond which the granite does not extend. The section southward from the end of Witch Bay, shows that the strike of the rocks bends around as the granite is approached from east to east-south-east, and in the north-east arm of Yellow Girl Bay the rocks strike N 35° E, so that there is a decided convergence, pointing directly to an arrangement of the strata concave towards the granite mass. The curve traced by the strike being assumed concentric with the

Definition of granite area.

Its outline.

general outline of the upheaved mass of granite, the latter must be limited on the east at a distance considerably within its extreme possible extension, as determined by actual observation on the Adams River.

The forces of upheaval which operated with greatest intensity in the central portion of the peninsula, and resulted in the extrusion from below of the main mass of granite also acted in lines radiating from this centre of activity, as is evident from the disposition of the smaller granite patches and dykes with reference to it. The club-shaped extension from the main mass to the shore of the lake at Yellow Girl Point, is continued in the same south-west direction, in a series of granite intrusions, portions of which are accessible to observation upon the islands for a distance of seven miles. The south end of Sepulchre Island is occupied by the same granite as that on Yellow Girl Point, and excellent exposures of it may be seen cutting the schists of the north end of the island, in dykes branching out from the larger mass. A mile and a-quarter south-west of Yellow Girl Point is a small island, the south half of which is occupied by granite, and half a mile west of this the eastern extremity, with a short portion of the south shore of Chisholm Island, is faced with granite. Between this and Beacon Island are a number of small islets, some of which are cut by granite dykes. Beacon Island lies a little less than a mile to the south of Chisholm Island, and is about a mile and a quarter from east to west, and a quarter of a mile in breadth. The south half of the island is all granite, with a feeble gneissic foliation developed in it at places in the neighborhood of its contact with the schists to the north. The point of land on the main shore immediately to the south of the west end of Beacon Island, is occupied by the same granite. Granite dykes traverse the schists on the east side of Cliff Island, and two small islands to the east of it are composed of granite, which is gneissic in places. Finally the centre of Cliff Island is occupied by a boss of granite with off-shooting dykes, which lies in the axis of an anticline, to the curve of which it seems to stand in the relatation of one of the foci of an ellipse.

Connected lines of upheaval.

Intrusions to south-west.

At right angles to this train of granitic irruptions branching out from the main Yellow Girl mass is another trending from it in a north-westerly direction. This line of irruption lies in the axis of the peninsula, and forms the back-bone, as it were, both of the tapering portion of the peninsula and of the ridge marked by the belt of close-set islands, which connects its extremity with the opposite side of the lake at Crow Rock Channel.

Intrusions to north-west.

This line of irruption and the ridge, of which it constitutes the axis or back-bone, is concave to the south, and both are apparently continued to the south-west of Crow Rock Channel, in the centre of the

Connection with Deadman Portage area.

Western Peninsula, so that there is established a continuous curvilinear line of upheaval, extending between the large Yellow Girl granitic mass in the centre of the peninsula, and the equally large area of irruptive granite which constitutes the nucleus of the Western Peninsula, in the neighborhood of Deadman Portage.

The first accessible exposure of this train of irruptive masses is on the shores of Bottle Bay. A long, narrow and apparently lens-shaped intrusion of granite crosses the bay in a north-west direction, and is plainly observed to cut the massive green schists on either side. It is accompanied by a number of small dykes, and these and portions of the larger mass have often, by a more rapid local cooling, been rendered so fine-textured as to be micro-granites or felsites in aspect, although for the most part the granitic texture is well developed.

Granite irruption an anticlinal axis. This lens-shaped irruption of granite constitutes a true anticlinal axis, there being, as is shown in another place, the same sequence of rocks on either side of the median line of upheaval dipping in opposite directions away from it. The projection of this axis of upheaval west of the French Narrows is a line covered for some distance by the waters of the lake, Allie Island being just to the south of it. Where the line first meets with land, however, on the east side of Oliver Island, the rocks are again found fissured and traversed by another lens-shaped granitic intrusion, which crosses Oliver Island, and is exposed on the shores of the channel between it and Shammis Island. The rock is highly feldspathic and fine-textured, and although it might be classed with the felsites is undoubtedly a granite in composition, and in places the granitic texture is not lacking. Half a mile to the south of this granite mass, on the east side of Shammis Island, is a large dyke of the same rock abutting upon the shore-line. A portion of the south shore of Shammis Island near its west end is faced with granite, and an island a quarter of a mile long, lying opposite the channel between Shammis and Crow Rock islands is composed of it.

Dykes at Crow Rock Island. The east end of Crow Rock Island is traversed by at least two large dykes, which strike with the schists and come out upon the shore facing Shammis Island. A number of large, somewhat irregular dykes is seen also to the west of Crow Rock Island. The east side of Micrometer Island, a little to the north of Crow Rock Channel, is occupied by a coarse-textured gray granite intrusive through the schists. Both sides of Crow Rock Channel expose irruptive masses of reddish granite of normal texture, which are continued in a series of dykes running with the schists along the shore to the west-south-west of the channel, and which are probably farther continued and merge into granitic offshoots from the Deadman Portage area.

The Deadman Portage Granite Area.

The tracing out of the line of anticlinal irruptions, which radiates from the Yellow Girl mass in a north-west direction, and then curves around to a west-south-west direction towards Crow Rock Channel, leads us naturally to an area of granite which stands in a relation to the Western Peninsula and the strata which compose it, analogous to that which the Yellow Girl mass bears to the Eastern Peninsula and its rocks. The Deadman Portage granite area comprises two distinct masses. The first of these is chiefly exposed on the shores of Carl Bay, on the Shoal Lake side of the portage. It is oblong in shape, the longest direction of the mass running from north-east to south-west. In this direction it has been definitely ascertained to have a length of at least four miles and a-half, but its extension to the north-east of Carl Bay probably adds considerably to this observed distance, so that its total length may be taken at about seven miles. It has a breadth transverse to this direction varying from a mile to a mile and a-quarter. **Central mass of Western Peninsula.**

The continuous line of exposure afforded by the shores of Carl Bay, and its relations to the rocks on the south, (revealed by sections examined over a comparatively bare country,) show that the mass is intrusive through schistose hornblende-rocks. On its northern border there has been developed in the granite a distinct foliation, the planes of which are arranged parallel to the line of contact with the schists, so as to form a border or selvage of gneiss, from an eighth to a quarter of a mile in breadth between the more granitic portion of the mass and the hornblende-rocks. The hornblende-rocks in contact with this gneiss on the north side of the intrusive mass are blackish-green in colour and fissile. On the south side of the mass the foliated structure was not detected in the granite in the vicinity of its contact with the hornblendic rocks, which were also, it is interesting to note, much more massive and less schistose than those on the north side. In crossing the neck of land which separates Carl Bay from Portage Bay and at the narrowest point of which is the canoe-path known as Deadman Portage, we traverse a belt of rather massive schistose hornblende-rocks, with some trappean rocks of undefined relations to the schists, the whole having a breadth in the line of the portage of about a mile. This belt of schistose hornblende-rocks and traps separates the Carl Bay granite mass from that of Portage Bay on the Lake of the Woods side. This mass of granite occupies the shores of the eastern part of Portage Bay and almost the whole of the peninsula that separates it from Outer Bay. Its greatest length is about four miles in a direction nearly parallel with the longer axis of the Carl Bay mass, and its greatest breadth is a mile and a-half. The irruption has taken place **Character of junction with schists.**

along the line of contact of the schistose hornblende-rocks, which lie to the west of it, and a thick group of micaceous and greenstone agglomerates which lie against it on the east. The granite has apparently forced the two formations apart to make room for itself, since the strike of the schists is concentric with its periphery, and the long axis of the granite mass is in a line with the common strike of both hornblende-schist and agglomerate when seen in its normal north-east and south-west direction at their contact in the north-east arm of Portage Bay.

Boundary to the south-west. The boundaries of this granite mass are well defined by exposures affording easy facilities for observation, except to the south-west, and in this direction its extension is limited by a bush traverse westward from the most northerly arm of Monument Bay, which proved that the granite does not extend that far. The irruptive energies which gave rise to the granite were not, however, altogether expended on the main mass at Portage Bay, for farther to the south, on the shores of Monument Bay, large dykes with a north and south trend are found cutting the schists. Two of these are observed in the north-east part of the bay and two others at its western end, all composed of the same granite as that of Portage Bay.

Dykes.

Granite assuming a gneissic aspect. It is altogether probable that the area of coarse-textured grey rock, colored on the map as gneiss, occupying part of the south-east shore of Shoal Lake, and a number of the outlying islands, is associated in origin with the granite mass of Carl Bay. It lies in the same general axis of irruption, and although its relations to the adjoining rocks are not sufficiently observable to decide definitely whether it is an irruption or not, its roughly foliated texture which claims for it the name gneiss, by no means precludes the possibility of its being a true irruption. In some places, as on Elm Island, this rock is granitic in texture as well as in composition, no foliation having been developed in it. The grey color of this rock is in harmony with what seems to be a rule of general application in this region, that where a granite, of true granitic texture, merges into a foliated variety of the same rock, there is a differentiation in color as well as in structure, the granite being for the most part red and the gneiss grey.

Associated felsites. Associated with the granites of the Deadman Portage area is another class of acidic irruptions of secondary character. These are lithologically classed with the felsites, which here as elsewhere occur as intrusions in the vicinity of large granite masses. In the intrusive area under consideration these are of two kinds, (1) a fine, even textured, whitish, to honey-colored felsite, with sparsely distributed grains of clear quartz; (2) a grey porphyritic rock, described as a felsite or micro-granite (Section No. 44, p. 35 C C). A small patch of the first of

these breaks through the green schists of the south side of Carl Bay close to the portage. Another boss of the same felsite occurs in the hornblende-schists about a mile west of the bottom of Monument Bay.

The second variety of felsite is however much more largely developed. A large mass of it breaks through the belt of hornblende-schists that intervenes between the granite masses of Carl and Portage Bays and is well exposed on the shores of Portage Bay and Partridge Lake. Its extension south of the latter lake is conjectural; but the occurrence of so large an irruption of the character of a felsite porphyry or micro-granite, in such a relation to the two extensive masses of typical granite is very interesting. Whether it is the result of an earlier or later manifestation of the same irruptive energies that gave rise to the granite or is contemporaneous with it, there is no direct evidence to show. It is altogether probable, however, that all three have had a common origin, and that the micro-granite differs from the true granite, not in age, but in conditions of pressure and rate of cooling which have decided the differentiation of the crystalline structure of the resulting rocks. A smaller mass of the same micro-granite is observed interrupting the agglomerate-schists of the north shore of Monument Bay, through which it is probably also irruptive as is indicated on the map.

Large felsite mass.

The Canoe Lake Granite Mass.

Thus far we have seen that within the Keewatin area the two prominent masses of land, the Eastern and Western peninsulas, whose resistance to denudation has been such as to prevent their degradation to the submerged level, to which disintegrating forces have reduced so large a portion of the area, have had as their nucleæ or central portions extensive irruptions of granite. To the north-west of the Western Peninsula lies another irregular peninsular mass of land, separating the waters of Shoal Lake from those of Ptarmigan Bay. This also has for its nucleus an immense boss of irruptive granite. This intrusion it is convenient to refer to as the Canoe Lake granite mass from the lake of that name, on the canoe route from Ptarmigan Bay to Shoal Lake, on the shores of which it is continuously exposed. It is a coarse textured, red, biotite granite with probably some muscovite. It breaks through a group of coarse and fine-textured trap-rocks, and fine-textured compact slightly schistose hornblende-rocks, the schistose structure varying much in intensity both in the traps and the hornblende-schists. The intrusion marks the development of a well-defined anticlinial dome, the dip of the rocks wherever observable all around the peninsula being away from the central mass of granite.

Third nuclear granite mass.

Exposures defining it good. The exposures upon which the mapping of this granite irruption is based are sufficient to place its extent and relations to the confining rocks beyond conjecture. On the south side of the west end of Echo Bay the shore, for the distance of a mile, is composed of it, much mixed towards the western end of this distance with portions of the rather massive, fine-textured, hornblendic schists through which it breaks. Granite becoming a felsite These schists, in the vicinity of the contact, are here also irregularly mixed with intrusions of a felsitic rock, which is probably simply a modified form of the granite. At the eastern end of the same distance the granite as it approaches the contact of the schists displays a very marked tendency to become fine-textured and assume the aspect of a red felsite rather than of a granite. This felsite-like modification, which very probably owes its physical condition, as contrasted with the true granite, to the greater rapidity with which it cooled near the contact, also exhibits a marked tendency to split in different directions under the hammer, as if a crude kind of schistose structure had been developed in it. A very distinct transition may be traced from this felsite or micro-granite variety of the intrusion to the coarsely granular varieties, within a distance of a hundred feet, and the feeble schistose tendency was observed to persist even beyond the point at which the granular structure became distinct. A portage of about ten chains, to the south leads up to Canoe Lake, on the whole of the shores of which the granite is well exposed, to the portage at its western extremity whereby we descend to the level of Shoal Lake, by a rough path about a quarter of a mile in length. Brecciated contact with Keewatin rocks Near the western end of this portage the line of contact of the granite with the hornblendic rocks is crossed. The contact here is distinctly brecciated, the granite penetrating the schist in large dykes and holding broken fragments of it. At the mouth of Bag Bay the contact is again well seen and the intervening breadth of schists between this and the contact on the portage just referred to is cut by transverse dykes of granite branching out from the main mass. In Bag Bay the granite is continuously exposed, and sends off dykes into the schists at its contact with them on the south side of the bay. On the south side of the peninsula the granite is next exposed at the bottom of Hell-diver Bay.

Isolated mass. Following around the south-western shores of the peninsula an exposure of granite occurs on the Shoal Lake Narrows near where it widens into Labyrinth Bay. This was at first supposed to form part of the same granite mass as that which I have been describing, but an excursion through the bush over a bare stretch of country, from a point on the shore to the north of it, proved its isolated character. A variety of hornblende-schists, coarse diorites and serpentines occupy the area between it and the larger mass, while in the vicinity of its exposure

on the shore of the narrows the rock is chiefly an altered diabase-schist. The next exposure of the granite mass met with is one of over a mile in extent on the western shores of Squaw Lake, whereby access is afforded well into the heart of the peninsula from the Ptarmigan Bay side.

Concentric felsitic intrusions.

The longest axis of this mass of granite measures six miles, and lies parallel to that of the Carl Bay mass in an east-north-east and west-south-west direction. The breadth of the mass is three miles.

A very interesting feature connected with this extensive intrusion is a series of concentrically arranged felsite intrusions which break through the schists at a certain comparatively uniform distance from its border. These may be noted briefly in order, the map being chiefly relied upon to give an idea of their relationship to the granitic mass. The first has already been referred to as the purple felsite described by Mr. Bayley in section No. 28 (p. 34 C C.) It occupies the extremity of a point of land on the south side of Echo Bay, apparently intrusive through the hydromicaceous schists that form the shore. Whitish felsites occur, as has been noted, breaking through the schists near their contact with the granite at the extreme west end of Echo Bay. On the north side of Clytie Bay are two large patches of similar whitish to honey-colored compact felsite, whose irregular relation to the green schists of the shore is quite suggestive of an intrusive origin. The first of these occurs at a distance of half a mile from the contact of the schists they cut with the granite, and the second and larger is half a mile farther west. On the outer side of the arm of land which separates Bag Bay from Shoal Lake, and on the off-lying islands, are a number of these felsite intrusions. Of these a whitish felsite described as Sections No. 42 (p. 34 C C) is a fairly typical example, and is taken from an island composed of it which lies a mile and a-quarter south of the entrance to Clytie Bay. A mile south of this island the narrow projecting strip of land which forms the turning point of the shore is entirely composed of the same felsite. A mile and a-half south-south-east another mass of it is seen, on the west side of a small bay, while the east side of the peninsula which separates this bay from Hell-diver Bay is almost entirely composed of the same rock, which is seen on the south side of the west end of the latter bay to cut the schists in distinct dykes. One or two other instances of similar occurrences of felsite of small extent were observed on the same shore farther east.

Their character

Regarding all these felsitic intrusions in their relation to the granite mass, we find that they lie in a belt concentric with its border, from which they are nowhere more than a mile and a-half distant, and that they appear to have had the most favorable conditions for their occurrence on the north, west and south sides of the granite, although

the fact of their not appearing on the east side is very possibly due to difficulties of observation, there being a considerable breadth of country between the shore-line and the granite in which such intrusions may exist without being apparent on the chief line of exposure along the shore. These felsites seem to bear an analogous relation to the Canoe Lake granite as to that borne by the mica-granite and felsites of the Deadman Portage area to the granites there, and, like them, are probably associated genetically with the granite.

Subordinate granite bosses continuing main mass.

The irruptive forces which gave rise to the Canoe Lake granite mass, show evidence of having extended their activity far beyond the main intrusion and beyond its encircling zone of felsite dykes. If the longer axis of the Canoe Lake mass be projected east-and-west, it will be found to pass in the immediate vicinity of subordinate granite bosses on either side. On the west side this projected axis of irruption is seen to be coincident with the axis of a great anticline, which brings the lower granitoid gneisses to the surface in Snow-shoe and Rice Bays, and on the shore of Shoal Lake for three miles to the south of these. This upheaved area of granitoid gneiss is cut, where it forms the west shore of Shoal Lake, by intrusions of granite which are grouped about a line that forms the common axis of the upheaval and of the Canoe Lake irruption. These granites are very red in color and coarse-textured, and present a sharp contrast to the lighter colored gneiss through which they break. They are exposed in two distinct patches on the shore, with a small breadth of gneiss intervening, and on the outlying islands, as represented on the map.

Three subordinate intrusions.

The eastward extension of the same axis of upheaval or irruption has, grouped about it, three subordinate intrusions. The central of these is almost exactly in the line, and takes the shape of an irregular, large, dyke-like patch of granite, cutting the agglomerate-schists on the south side of the west end of Ash Bay. Its granitic structure is well developed in some places, but for the most part, its texture is that of micro-granite. It is flesh-red in color, and displays a crude sort of cleavage under the hammer. It resembles very closely the selvage of red felsite, described as characterizing the northern limits of the Canoe Lake granite mass at its contact with the schists on the shores of Echo Bay. To the south-east of this, on the north side of Labyrinth Bay is a small boss of granite, which seems to occupy the heart of an anticlinal arrangement of the schists through which it breaks, as will be seen from the structural section C–D. At the narrows, between Copper and Cork-screw Islands, an irregular intrusion of granite cuts the schists on either side. In places it breaks up into distinct dykes, and is associated with a whitish felsite rock on its north side, which doubtless bears the same relation to it, as do the encircling felsites to the Canoe Lake mass.

The Indian Bay Granite Mass.

This is an intrusion of considerable extent, though much less in size than the Canoe Lake mass, and is a coarse-grained, red granite. Its extent as mapped, is inferred from a continuous exposure on the north shore of Shoal Lake, and another at the eastern end of Indian Bay, taken together with the strike of the rocks that surround it. As will be seen, its long axis has, approximately, the same direction as that of the Canoe Lake mass and of the Carl Bay mass.

The south-eastern confines of the mass are in contact with a breadth of mica-schist, in a vertical attitude. At its western extremity, where exposed at the east end of Indian Bay, it is also in contact with mica-schist. At the western end of the Shoal Lake exposure there is a marsh-covered interval between the granite and the next rock to the south, which is a massive hornblende-schist, merging into a greenstone-schist. This covered interval probably represents that occupied by the mica-schists, as it is in the same relative position with regard to the granite as are those mica-schists above mentioned, and lies between them. Thus it is probable that the granite is in contact along the whole of its southern border with mica-schist. On its northern border, on the Indian Bay side, the mica-schist is not seen, and a schistose hornblende-rock is the nearest observed to the granite. We have no warrant for assuming that the mica-schist completely encircles the mass, although it is continuous around half of its border. Outline of mass

A small patch of granite, cutting the gneiss, of Snow-shoe Bay, near its contact to the north with the agglomerate-schists at the mouth of the bay and the granite of an island about half-way between the entrance of Indian Bay and that to Clytie Bay, may be regarded as probably associated with the Indian Bay mass. Granite on Snow-shoe Bay.

The Big Narrows Island Granite Mass.

The general relations of this granite mass to the structure of the strata, may be best described by saying, that it lies in a secondary curvilinear axis of upheaval, to the south of, and concentric with, the main arch of granitic irruption, of which the nuclear bosses of the Eastern and Western peninsulas are, so to speak, the supporting buttresses. The mass occupies the central portion of Big Narrows Island. Its presence at this point seems to have conditioned the size and shape of the island. The latter is one of the largest in the lake and its general outline is that of a lens, tapering to slender points to the north-east and south-west, and having the granite as a nuclear mass in the line of its greatest thickness. The granite occupies an area, in General relations of this mass.

the west of the island, a mile and three-quarters in length, and a little less than a mile in breadth. The granite varies in texture and in color. For the most part it is an ordinary coarse-grained, red granite. Near its contact with the schists, at the mouth of Turtle Bay, however, it assumes, in places, a very coarse, pegmatitic structure, with but little mica present. On its northern border, as exposed on the south side of Quandary Bay, there is developed in it a fairly, well-marked gneissic foliation of the constituent minerals. When this gneissic structure exists the feldspar is less red, and the whole rock is, in consequence, of a much lighter colour, tending to appear in grey rather than in red tints, as found in other cases under the same circumstances.

Relations. The exposures are sufficient to determine, with moderate accuracy, the extent of the mass and its relations to the confining rocks. The intrusion breaks through mica-schists, or micaceous quartzites, the strikes of which, where not immediately interrupted by the granite, tend to curve around it and converge at either end. On both sides of the granite mass the schists are, at their nearest exposures to the contact, in a vertical attitude, but a little farther away they are seen to dip at high angles towards the granite.

Quandary Bay. Some patches of dark-green hornblende-schists, small in area, are observable on the shores of Quandary Bay, apparently intervening between the granite and the mica-schist, and on the south side of Turtle Bay there is a considerable exposure of a rather massive green schist, quite chloritic, which is surrounded by the mica-schists, but does not reveal its structural relations to them. On the south side of the mouth of Quandary Bay, a patch of schist-agglomerate, in contact to the south with a fragment of a belt of mica-schist, is partially surrounded by the granite, and has apparently formed at this place the confining rock of the aperture of irruption. In the same line of irruption there is found on the north side of Rope Island a mass of gray granite, about a quarter of a mile in extent.

The general attitude of the rocks of Big Narrows Island is that of a synclinal fold, and it would appear as though the granite had been intruded from below at a date posterior to the formation of the syncline, so that although it is quite correct to speak of the line of injection as an axis of upheaval, the upheaved rocks had probably already in a large measure been folded.

Relations of other granite masses. The two other important granite areas, viz: the North-west Angle area and the Sioux Narrows area bear somewhat analogous relations to the general distribution of the Keewatin rocks. The one lies to the south-west of the Keewatin area, and the other to the south-east of it, and both are in the immediate vicinity of its contact with the granitoid Laurentian gneisses. The one is at the western extremity of the exten-

sive schist-surrounded dome of granitoid gneiss, presented in the Grande Presqu'isle, and the other lies approximately at its eastern extremity.

The North-west Angle Granite Area.

This area lies opposite the mouth of the North-west Angle Inlet and is described to some extent under the above name by Dr. G. M. Dawson, who, however, in his reconnaisance of the lake did not attempt to map the distribution of the granite definitely. As mapped on the sheet accompanying the present report it appears as a cluster of sporadic patches of granite, stretching from Flag Island to the north end of Falcon Island, and lying between the latter island on the east and Windigo Island on the west. The sporadic character of the granite is more apparent than real, however, and is due to the irregular distribution of land and water, the latter often concealing the connection between different masses of granite. These occur in such a way that none can be proved to be completely isolated from any other, so that possibly there may in reality be but one irruptive mass. It appears probable, however, that there are three distinct masses at least. The first of these occupies the northern portion of Fly Island, the south end of Wind-fall Island, Passage Island, Cyclone Island and the small islands to the south of it. The second comprises the granite of the west and north sides of Wind-fall Island, the north-east tip of Windigo Island, the granite of the small islands between the latter and Falcon Island, and the two more southerly patches that appear on the west shore of Falcon Island. The third mass consists of the granite patch near the north end of Falcon Island and on some off-lying islands. The granite is mostly red coloured, and coarse-grained, sometimes with porphyritic crystals of feldspar. The mica is prevailingly black. The rock is nearly everywhere intrusive through the granitod gneisses of the Laurentian, the exceptions being the part on the north-east end of Windigo Island, which appears at the contact of the gneiss with an infolded belt of black hornblende-schist, (the intrusive rock cutting and forming a breccia with both gneiss and schist) and the granite of the west side of Wind-fall Island, which is in contact to the west with some agglomerate-schists and dioritic breccia. The intrusive character of the granite cannot always be demonstrated, inasmuch as where it occupies entire islands no contact features are observable, and in a few places, particularly on the west shore of Falcon Island, there does not appear to be a distinct line of separation between the granite and the gneiss. In other cases, however, where the contact is observable, the granite is seen to cut the gneiss and is unmistakably intrusive, so that the intrusive character of the whole may be fairly inferred.

Sporadic appearance on map.

Character and distribution.

Dykes and veins.

The red granite of the south end of Wind-fall Island contains sharply angular blocks of black hornblende-schist, some of which are traversed by small irregular veins of white quartz, which terminate abruptly upon the contact face of the granite, thus showing that the veins existed in the hornblende-schist prior to its inclusion within the irrupted granite. The activity, which found its strongest expression in the granite irruptions that cluster around Wind-fall Island, makes itself manifest for considerable distances beyond this. Smaller dykes of granite cut the gneiss beyond the limits assigned to the area. A number of these are observed cutting the gneiss on American Point, and on the shores of the inlet to the west of it, and the south-west end of Poplar Island is occupied by a boss of granite which forms a well-defined breccia with the mica-schists through which it breaks. This lies in the same axis of folding as the granite of Cyclone Island, and seems to indicate a chain of connection between the North-west Angle granite area and that of Big Island and Painted Rock, the other links of which are concealed by the waters of the lake.

Granite boss.

The Sioux Narrows Granite Area.

Distribution and character.

The main mass of granite in this area of irruption is well exposed on both sides of the Sioux Narrows, towards its eastern end, and on the islands that lie between. Geologically it occupies the central portion of the narrow belt of hornblende schists and associated traps that stretches out from the south-east corner of the area of Keewatin rocks, and connects them with the larger developments of the same series in the country to the east of the Lake of the Woods. The long axis of the mass is coincident with the strike of the belt and of the strata which compose it. Its greatest length in this direction, so far as it has been observed, is about four miles, but it probably extends much farther eastward than it is mapped, under the waters of the lake. Its breadth is about two miles. The granite varies in color from reddish to pinkish-grey. In texture it is mostly coarse-grained, but in places, especially at the east end of the Narrows, on the south side, it merges into a very fine-textured, compact, reddish felsite-like rock, similar to that described as constituting the northern border or selvage of the Canoe Lake granite mass as exposed on Echo Bay.

Contact breccia

To the west of this main mass of granite, and occupying the south shore of the Narrows for the distance of a mile to the east of the narrowest part, is a brecciated mixture of the granite and schist. The green schists have been shattered and fractured in every direction, and the fissures have been injected with granite, so that the original country rock is now seen to be penetrated by innumerable,

anastomosing dykes which form so large a proportion of the present rock as to give it all the characters of a breccia on a large scale.

Just west of this breccia on the same side of the narrows is another mass of granite, exposed on the shore for about three-quarters of a mile, and on two of the off-lying islands. Smaller granite masses.

Half way between the Sioux Narrows and Rendezvous Point is another somewhat extensive boss of red granite lying in the line of junction of the hornblende-schists and granitoid gneiss, both of which it cuts. It is about two miles in length in a direction transverse to the line of junction which it interrupts, and is at least over half a mile in breadth, possibly a mile, as its limits have not been traced out on its north side. This boss and a smaller one breaking through micaceous schists at the east end of Yellow Girl Bay are in a line with the Yellow Girl granite mass and that of Sioux Narrows, and would thus appear to form a chain of connection between them. Still another boss of granite, that may for convenience be grouped with the Sioux Narrows mass, was observed, on a bush traverse, cutting the gneiss about a mile and a-half north of the north shore of Long Bay. It is a coarse-textured red granite. The extent of its distribution is not known.

Poplar Bay Granite and Quarry Island Gneiss.

Within the area of the Keewatin rocks there are two other isolated irruptive bosses to be noticed. The first of these is the Poplar Bay granite, a reddish to flesh-tinted, coarse-grained rock breaking through green schists on the north side of the bay and on the larger island in its central portion. This has a length of about a mile in a north-northeast direction and a breath of half a mile. The strikes of the rocks of the bay display a tendency to arrange themselves parallel to the edge of the granite, although those in its immediate vicinity appear massive and do not afford satisfactory observations for the strike. The dip is irregular in direction sometimes away from and sometimes towards the granite, but always at very high angles. Other granite bosses in Keewatin rocks

The Quarry Island boss lies in the axis of what appears to be a fold in the strata, the terminal portion of which runs out into the area of the granitoid gneisses in the tongue of schists at Pine Portage. Its exact extent has not been definitely determined, especially on its north side. It is, however, well exposed on the channel between Quarry Island and the main shore, and its distribution on the former has been pretty well made out. In these exposures it is seen to be a very coarse-textured gray granitic rock presenting a roughly but distinctly foliated structure. Its length is probably about a mile, and

lies in the direction of the median line of the stratigraphical fold indicated by the distribution of the rocks in the neighborhood of Pine Portage. Its breadth is half a mile. The boss is intrusive through more or less massive green schists, and on its west side the gneiss seems to have become intimately mixed with its contact rock, giving rise to a schist of transitional character between the gneiss and the country rock. This schist, though a coarsely-textured rock, presents a ready cleavage which has the aspect of a slickensided surface, as if the schist had been developed by a process of rubbing or slipping along the contact of the gneiss with the green schist.

Split Rock Granite.

Granite mass in gneiss.

This granite mass breaks through grey, coarse-textured, granitoid gneiss on the peninsula which forms the north-east extremity of Split Rock Island. The same granite occupies the island lying off the extremity of the peninsula, as well as the island immediately to the south of this. It also forms the shore for several miles of the north-east end of Big Island. The rock is, for the most part, of a red color, and is a typical granite. It is interesting, as compared with the other granitic areas that have been described, in being confined wholly within the Laurentian gneiss.

General Conclusions respecting Granite Masses.

Having considered briefly the leading features of the various granitic irruptions that occur within the field, it may be well to state, in short form, the general conclusions which seem to be fairly deductible from the observations made.—

Age, relations and character of the granite masses.

(1) The granite cuts both the granitoid gneiss (Laurentian) and various rocks of the Keewatin series, and is therefore of later age than either.

(2) The granite masses have a definite relation to the stratigraphical structure.

(3) They appear to lie in the lines of folding, with much of which they have been concomitant, primarily as an effect due to the same cause as that of the folding, and secondarily, as a cause of folding and pressure.

(4) A granite, the intrusive characters of which are undoubted, may merge in the same rock-mass into a granitoid gneiss without the latter losing those distinctive characters or proofs of its intrusive origin.

(5) The granite is, as a rule, a red-colored, biotitic, muscovite granite, of coarsely granular texture, but wherever a gneissic foliation has been developed in it, the rock tends to lose its red color and become grey.

(6) In the same rock-mass, towards its borders, the granite may have cooled into a compact-textured, homogenous, felsite-like rock, in which is not infrequently developed a crude sort of cleavage.

(7) There is a marked association of felsites, or micro-granites, with the main granite masses, there being an apparent tendency on the part of the former to an arrangement concentric with the periphery of the granite.

The Stratigraphical Relations and Structure of the Rocks Constituting the Keewatin Series.

A consideration of the general aspect and geological conditions of the series of rocks with which we are dealing seems to warrant the assumption, already alluded to, that they have been laid down in and folded within a trough in the Laurentian formation. This assumption is strengthened by an investigation of the stratigraphical structure of the belt within which they are comprised. By way of preliminary to a statement of the results of such an investigation, we have thus far reviewed (1) the lithological character of the more typical rocks; (2) the conditions found to obtain along the line of contact of the basal members of the series with the granitoid gneiss on the borders of the trough; and (3) the leading features and distribution of granite irruptions, which have played so important a part in the development of the structure of the belt. Resumé of points already treated.

A very cursory examination of the field is sufficient to establish the fact that there enters into the formation of the series a number of distinct and well characterized groups of rocks. The determination of the mutual relations of these groups, however, of their relative places in the the stratigraphical column, or in geological time, is a problem attended by many difficulties, and presenting no very satisfactory solution. Some of the difficulties that are encountered in this particular field may be mentioned here, since it is desirable that they should be carefully weighed in the estimation of the results arrived at. Different component parts.

(1) The strata throughout the field are tilted at very high angles, and inversions are not infrequent, so that the order in which the rocks are met with, across the strike, gives no clue in itself as to which are the higher or lower members of the series. Difficulties met with in correlation.

(2) The rocks are quite devoid of such aids to correlation as fossils.

(3) The conception of the series as a mixture of altered volcanic ejectamenta and aqueous sediments, laid down sometimes syncheonously, and sometimes in alternations, implies the accumulation of overlapping and interchanging strata, differing in lithological char-

acter, some of which might be largely developed in one portion of the basin, and be very meagerly represented or altogether wanting in another at no great distance away. Such irregularities in the stratification, though perfectly in accordance with the ordinary processes of nature, seem to be strongly accentuated in these ancient formations; and in proportion as the rocks are folded these irregularities become more difficult of specific explanation, though readily enough accounted for in a general way. There is even a possible source of error in the tendency on the part of an observer familiar with the comparatively uniform conditions which obtain in the later fossiliferous rocks, to look for and pre-suppose a regularity in stratification which does not exist in nature.

(4) To satisfactorily correlate the rocks, it is therefore necessary to trace them closely from point to point; but this the nature of the ground and the large expanses of water often render impossible. Hence a certain amount of conjecture is introduced which is not present in the working out the relations of fossiliferous strata.

Description of Section C-D.

The most convenient method of approaching the question of the geological composition of the series and the mutual relations of its various members, is to consider a section across the belt, where the rocks seem to be typically developed, regarding the conditions there presented as typical for the area, and as a standard for comparison with analogous conditions found in other portions of the belt. For this purpose I have selected the section indicated on the map by the line C–D, as best suited to illustrate the character of the belt across its entire breadth. This section is over twenty miles in length in a direction transverse to the strike of the strata, and cuts the belt about its middle.

Groups of rocks met with.

The various groups of rocks met with in this section are:—

Granitoid gneiss at either extreme.

Hornblende-schists with associated altered traps, the whole more or less chloritic.

Agglomerate-schists, varying in character from greenstones to micaceous or gneissic schists.

Quartzose mica-schists, sometimes gneissic but lamination very even.

Hydromicaceous and chloritic schists, and micaceous slates.

Granite (irruptive).

Apparent relationship of these.

A first glance at the section disclores little or no relationship or periodic arrangement between these various groups. The two extremes of the section, where the series is observed to be in contact with the granitoid gneisses, afford us, however, starting points from which to trace out the sequence. The nature of this contact at either end of the section, both at Rice Lake and at Beaver Inlet, has already been

described in previous pages. On the assumption that these granitoid gneisses are inferior to the Keewatin series as a whole, we have in the hornblende-schists, which lie in contact with them, the basal member of that series. Proceeding inward from this contact along the line of section, we ought to be able to trace out on either side of the belt the sequence of the strata in ascending order. This we can do, but unfortunately for our attempt to find a regular law in the natural arrangement of the strata, the sequence at one end does not correspond with that at the other end of the section, and we are confronted at the outset with that lack of uniformity which is so characteristic of the whole series, and which dissipates so unceremoniously any notions that may have been entertained of these strata having been laid down and folded like so many layers of cloth.

North side of belt.

On the north side of the belt there is seen in immediate contact with the black hornblende-schists, a breadth of a mile and a-half of northerly dipping agglomerate-schists, which in the vicinity of the section are more or less micaceous or gneissic in character, but which, traced eastward in continuous exposure along the shores of Clear-water Bay, merge directly into greenstone-agglomerates, composed largely of feldspathic and hornblendic or chloritic minerals and apparently clastic rocks of volcanic origin.

South side of belt.

On the south side of the belt there is in contact with the hornblende-schists, and apparently partially infolded with them, a group of mica-schists, which not unfrequently pass by an admixture of feldspar into evenly laminated, fine-textured, gray gneiss. There are three possible explanations of this disparity. Either both rocks are of strictly contemporaneous origin, depositions of different character having been laid down at the same time in the two different portions of the trough; or the mica-schist is of prior origin, there being no deposition going on in the northern portion of the trough while it was being laid down in the southern; or the reverse is true, and the agglomerate antedates the mica-schist, but was not deposited uniformly on top of the hornblende-schist throughout the area. The facts cited below indicate that the last is probably the correct explanation.

Periodic arrangement discernable.

Notwithstanding this lack of correspondence, however, between the sequence on the two edges of the belt, where we have a known base to start from, there is discernable in the section a certain periodic arrangement of the different groups of rocks. Going southward from the contact with the granitoid gneiss at Rice Lake the section shews a breadth of hornblende-schist, which, taking 75° as the average dip, is estimated to have a thickness of about 5,000 feet, a little to the east of the line of section, where not interrupted by the intrusive gneiss. Following this in ascending order we have a breadth of a

mile and a-half of agglomerate-schists, with some minor bands of intercalated hornblendic schists, and micaceous or hydromicaceous slates. These have a northerly dip at angles between 70° and 80°. Making allowance for the dip, these agglomerates have a thickness of about 7,650 feet. To the south of this, with a width of three miles, is a group of alternating bands of micaceous, hydromicaceous and chloritic schists and slates, exposed on the shores and islands of Ptarmigan Bay. The essential characters of this group are the predominance of hydromica and chlorite and the consequent soft, glossy fissile nature of the rocks. This breadth of three miles seems to be due to the duplication of the natural thickness of the group in a synclinal fold, so that, allowing for the dip, which is generally northward at high angles. its volume is estimated at about 7,500 feet. Thus we have, to the middle point of this belt of hydromicaceous and chloritic schists the following series:—

	FEET.
3. Hydromicaceous and chloritic schists and slates............	7,500
2. Agglomerate-schists......................	7,650
1. Hornblende-schists..............................	5,000
Total................................	20,150

Anticlinal of Labyrinth Bay.

Now if we turn to the granite boss of Labyrinth Bay, which, it has been pointed out, appears to lie in the axis of an anticline, and consider the sequence on either side of it, we find on the north side a breadth of half a mile of hornblende-schists and altered traps, mostly very chloritic and in a nearly vertical attitude. The true thickness of the formation can scarcely be ascertained at this point since it is interrupted and diminished by the granite intrusion, and is probably the only partially uncovered crest of an anticlinal fold. Further west, the breadth across the strike is about a mile, so that if the interpretation I have placed upon the structure as that of an anticline be correct, the formation has a thickness of at least half a mile or about 2,600 feet. Following this is a breadth of 1·3 mile of agglomerate-schists, which resemble in their character those of Clear-water Bay.

North side.

The dip throughout this bay is uniformly northward at high angles and the estimated thickness is about 6,600 feet. This is followed by the strata which constitute the southern half of the three-mile breadth of hydromicaceous and chloritic schists of Ptarmigan Bay. These were found to have a thickness of about 7,500 feet. Hence we have, reckoning from the centre of Labyrinth Bay anticline, the following series in ascending order:—

	FEET.
3. Hydromicaceous and chloritic schists and slates	7,500
2. Agglomerates	6,600
1. Hornblende-schists and traps	2,600
Total	16,700

To the south of the centre of the anticline we have the same sequence. In contact with the hornblende-schist group, where not interrupted by the granite boss, is a group of agglomerate-schists, dipping to the south, which have a thickness of about 2,400 ft. To the south of this we again find the hydromicaceous schists, though in considerably diminished volume. The schists dip south and their exposed breadth is about seven-eighths of a mile. This, however, appears to be (just as in the case of the similar rocks in Ptarmigan Bay) a synclinal duplication, and the real thickness as near as can be estimated is about 2,200 feet. Thus we have again the series:— South side.

	FEET.
2. Hydromicaceous schists	2,200
2. Agglomerate	2,400
1. Hornblende-schists and traps	2,600
Total	7,200

The series of granite irruptions, which I have described as stretching in an arch from the Yellow Girl granite mass in the heart of the Eastern Peninsula, to that which forms the nucleus of the Western Peninsula near Deadman Portage, is seen to be associated with an anticlinal arrangement of the strata. The line of section crosses this anticline midway between the south-east end of Labyrinth Bay and the bottom of Wiley Bay. The sequence on either side of the anticlinal axis is the same. The lowest member of the series, the group of hornblende-schists and traps, does not appear in its full volume here, but farther to the south-west it has a maximum thickness of 5,700 feet on either side of the Carl Bay granite, which lies in the line of the anticlinal axis. On the north side of the anticline the hornblende-schist group is followed by a group of agglomerate-schists which have a probable thickness of about 4,000 feet, and these are in turn in contact with the southern half of the synclinally folded group of hydromica and chloritic schists of Labyrinth Bay. Hence we have in ascending order:— Arrangement elsewhere on two sides of anticlinal.

	FEET.
3. Hydromicaceous schists	2,200
2. Agglomerate-schists	4,000
1. Hornblende-schists and traps	5,700
Total	11,900

On the south side of the anticline the hornblende-schists are followed by a breadth of a mile and a-half of agglomerate-schists, representing a thickness of 7,600 feet. These are in turn followed by a breadth of micaceous and hydromicaceous schists leaving a thickness of 3,800 feet on the line of section, although they appear to thin out rapidly to the south-west.

Here again, then, we have the same sequence in the series :—

	FEET.
3. Micaceous and hydromicaceous schists	3,800
2. Agglomerate-schists	7,600
1. Hornblende-schists and traps	5,700
Total	17,100

Synclinal at Big Narrows Island.

The attitude of the rocks around the Big Narrows Island granite mass is that of a syncline, the higher rocks being those in the immediate contact with the intrusion. Hence the sequence of the strata observed in approaching the granite along the line of section on either side is an ascending one. Now lying in contact with the micaceous and the hydromicaceous schists of the last series tabulated, is a considerable breadth of green, chloritic hornblende-schists and traps, with a generally southerly dip, though often quite vertical. These have a thickness along the line of section of 6,300 feet. These are followed by a band of agglomerate-schists, about 3,300 feet thick; and between these and the granite are mica-schists to a thickness of 1,530 feet. This gives us a series in ascending order analagous to the last, which it follows without any apparent stratigraphical break, thus :—

	FEET.
3. Mica-schists (quartzose)	1,500
2. Agglomerate-schists	3,300
1. Hornblende-schists and traps	6,300
Total	11,100

Going southward from the granite the same series is crossed in descending order. Thus we have first a band of mica-schists about 2,500 feet thick, then a band of agglomerate-schists which widens out rapidly to the west, but which, where cut by the line of section is not more than 1,500 feet thick. This is followed by hornblende-schists and traps, mixed somewhat with mica-schists, which have a thickness of about 2,500 feet. Tabulated the series is as follows:—

	FEET.
3. Mica-schists	2,500
2. Agglomerate-schists	1,500
1. Hornblende-schists and traps	2,500
Total	6,500

Southern border.

Between this series and the granitoid gneiss with which the belt is in contact to the south, the section shows only mica-schists and hornblende-schists, which may be arranged thus :—

	FEET.
3. Mica-schist	7,600
2. Agglomerate-schist (wanting)	
1. Hornblende-schist	3,500
Total	11,100

General three-fold arrangement.

Thus, reviewing the section as a whole we find in it what appears to be a very simple system of arrangement of its component groups of rocks. By arranging the different groups or formation of rocks in threes, and taking certain groups as common to two sets of threes, we have an eight-fold repetition of the same relations, with one exception due to the absence of a group. That is to say, we always get a combination of the three groups in which the agglomerate-schists occupy a middle position between the hornblende-schists and the mica- or hydromica-schists. The contact of the former with the granitoid gneisses, which are assumed to be the base of the whole, determines for it the lowest position in the series, and we have a definite sequence in ascending order of hornblende-schists, agglomerate-schists, and micaceous or hydromicaceous schists. If my interpretation of the folding of the strata be correct, this sequence is unvarying throughout this section of the belt. That interpretation will be gathered best from a consideration of the section C–D, where a restoration, in dotted lines, has been attempted of the original folded aspect of the belt. It may be described briefly thus :—

Number and arrangement of folds.

There are two anticlinal folds, crowded together in the central portion of the belt, with a common intermediate syncline, and wider synclines on either side, the outer flanks of which are in contact with the granitoid gneiss on the two parallel borders of the belt. This structure is not indicated so much by the dips of the strata as by the conditions attendant upon the granite irruptions, and the symmetrical arrangement of the strata on either side of the axis of such irruptions. A horizontal truncation of this double anticline, with the implied three synclines, such as denudation affords us on the natural surface of the ground, would shew a six-fold repetition of the vertical section of the series, as represented in the diagram at 1, 2, 3, 4, 5, 6.

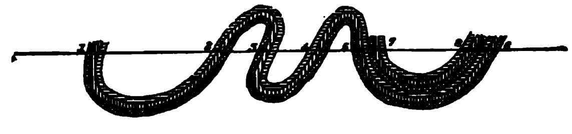

FIG. 12.—DIAGRAM ILLUSTRATING FOLDING OF KEEWATIN SERIES.

Eight-fold repetition in general section

We have, however, in the general section C–D an eight-fold repetition of the same apparent vertical sequence of groups. The two extra vertical sections (7 and 8) appear to belong to an upper or newer series of similar rocks, occupying the trough of the southern syncline of the lower series, in which the same groups of rocks have been deposited in the same order. These upper rocks would appear to form an integral portion of the general series of the rocks, so that in the sum of the two sub-series, the lower and upper, we have here a nearer approximation to the maximum development of the Keewatin series than elsewhere in the section C–D.

Total thickness of series.

If we take the average thickness of the three groups of rocks which enter into the composition, these lower and upper sub-series, as estimated from the six sections in the one case and the two in the other, and sum them, we arrive at a figure which may be regarded as an approximation, in a general way, to the average thickness of the entire series. Thus :—

		FEET.
Upper Sub-series.	6. Micaceous schist	2,000
	5. Agglomerate-schist	2,100
	4. Hornblende-schist and traps	4,400
Lower Sub-series.	3. Micaceous schist	5,133
	2. Agglomerate-schist	5,640
	1. Hornblende-schist	4,183
	Total average thickness	23,756

Description of Section A-B.

The section A–B, taken also transverse to the strike of the belt and lying from seven to ten miles west of the line of section C–D, presents many striking diversities from the stratigraphical arrangement displayed in the latter which has been assumed to be typical for the series in this region. It is chiefly interesting (1) in cutting across four large and important masses of intrusive granite; (2) in shewing a marked difference in the character of the strata which form the northern and southern halves of the belt; and (3) in showing both the north and south flanks of the belt dipping *under* the granitoid gneisses. In the southern half of the section, if we take the hornblende-schists and traps of Deadman Portage and those of the north shore of Falcon Island as the same formation, constituting the edges of a synclinal trough, in which the intermediate strata repose, in accordance with the interpretation placed upon the structure in the parallel section C–D, we find the sequence, as far as it can be traced satisfactorily, the same as that of the typical section. The basal group of hornblende-schists, which along the north shore of Falcon Island merges into a hornblendic schist-agglomerate, and dips under the granitoid gneiss, is but meagrely represented, and has a thickness of not much more than 600 feet. This

is followed by a wide band of agglomerate-schists, largely micaceous and quartzose, which have a thickness of about 7,400 feet. On the northern edge of this synclinal trough, the hornblende-schists and traps which form its edge, have a breadth of about 2,000 feet, but as they lie between two large masses of irruptive rock, the natural thickness of the formation cannot be satisfactorily estimated. The 2,000 feet of the same rocks that lie between the micro-granite irruptive mass, and the Carl Bay granite possibly form part of the same original thickness of strata, so that we would have a total apparent thickness of 4,000 feet. Following the hornblende-schists, just as on the south side of the trough, is a band of agglomerate-schists. The line of contact of the two has, however, in the vicinity of the section, served as the line of least resistance for the irruption of the Portage Bay granite, which thus separates them, and has evidently diminished the thickness of each. Thus far the sequence on either edge of the trough is the same and harmonizes with that found to hold generally in the section C–D. Beyond this the structure is less simple, and the central portion of the trough is occupied by a considerable breadth of mica-schists, fine-grained, evenly laminated, gray micaceous gneisses and agglomerate-schists, with some subordinate bands of green schists, the general stratigraphical relations of which cannot be satisfactorily determined, partly because the exposures are insufficient, being on scattered islands, and partly because these different rocks appear to merge into one another in such an intimate way that no hard lines of demarkation can be drawn between them. The *apparent* general arrangement of these rocks is given in the section, though in a very conventional way.

Central portion of section complicated.

North of the vicinity of Deadman Portage the section is largely occupied by irruptive granite masses, and the country in this direction having been, either as a concomitant or consequent condition of such irruption, upheaved to a greater extent, it would appear that the upper rocks had been more extensively removed by denudation. Thus, between the granite mass of Carl Bay and the Canoe Lake mass, the only rocks met with are those which would appear to belong to the basal group of the series and are chiefly hornblende-schist, altered schistose traps and some massive diabases and diorites, with a few subordinate bands of mica-schist. These have a continuous southeasterly dip at high angles till within a short distance of the Carl Bay granite, where the attitude of the rocks is reversed, and the dip is away from the intrusion to the north-west. These rocks probably lie in a syncline between the two anticlinal axes represented by the Carl Bay and Canoe Lake granite masses. These same rocks completely surround the Canoe Lake granite mass and are seen to dip away from it on all sides wherever the dip is observable. On the north side

Section north of Deadman Portage.

Synclinal at Indian Bay granite.

of the granite and between it and the granitoid gneisses, with which the belt is in contact on its northern edge, the strata have the arrangement of a syncline. The sequence from the contact of the basal group with the granite on the one side, and from that with the granitoid gneiss on the other, is practically the same, to the middle of this portion of the belt, which is occupied by the Indian Bay granite mass. This granite thus appears to be quite analogous in its structural relations to that of Big Narrows Island, since both appear in the heart of synclinal folds, which are symmetrically situated with reference to the median anticlines of the belt, and to its northern and southern margins. The sequence presented in the section of this syncline, in the axis which has been irrupted the Indian Bay granite, is as follows:—

On the south side:

	FEET.
3. Hornblende-schists and altered schistose traps, merging in places into greenstone agglomerates, and with some bands of mica-schist	7,600
2. Finely fissile, soft hydromica and chloritic schists, with some bands of hard, glossy, white and nacreous sericite-schists—very silicious	3,800
1. Black-green hornblende-schists, and traps more or less schistose and decomposed	4,600
Total	16,000

On the north side:

	FEET.
3. Hornblende-schist and schistose traps	4,000
2. Hydromicaceous schists, with some silicious and felsitic schists and bands of agglomerate-schists which merge into boulder-conglomerate, in which the paste is a chloritic schist, and the pebbles, round or oval in shape, of pinkish, felsite rock, around which the cleavage of the schist curves	7,200
1. Hornblende-schists	5,000
Total	16,200

Thus not only is the descending sequence of the groups of rocks on either side of the Indian Bay granite mass the same, but the total thickness of the series is practically the same in the two sections.

Synclinal traced east and west.

The interpretation of the structure of the folded strata in this part of the section as that of a syncline, is strengthened very much if we trace out the lines of outcrop of the different groups east and west of the section. The band of hydromicaceous schists, which curves around the north and north-west sides of the Canoe Lake granite mass, as exposed on Echo Bay and the north shore of Shoal Lake, may be traced south-

ward, through scattered islands, for a distance of four miles from the latter place, retaining the same curvilinear strike, concave to the granite mass, and the same dip away from it. At this point, which may be regarded as the point of contact of the curves of upheaval concentric to the Canoe Lake granite mass on the one hand, and to the granitoid gneiss and granite of Snow-shoe and Rice Bays on the other, these hydromica-schists appear to stop abruptly. I conceive that here the strike doubles on itself, and trending off sharply to the north-west, the same rocks are represented in the micaceous schists which are observed on the islands between this and the entrance to Indian Bay and in Indian Bay itself. The band thus indicated by isolated exposures, has a general direction concave toward the Snow-shoe Bay granitoid gneiss, just as it has to the Canoe Lake mass. The schists differ considerably in their general aspect from those of the band described as curving around the Canoe Lake granite mass. They are black and micaceous, and pass into dark argillite slates. The stratigraphical identity of the two formations can, however, scarcely be doubted, inasmuch as at the bottom of Indian Bay these black mica-schists and slates converge with the band which has been taken as the analogue on the north side of the syncline of the first of the same two formations. Near their convergence the two bands have the same lithological characters. But the northern band, just as the southern does, appears, on being traced eastward, to merge into soft hydromicaceous and finely fissile chloritic schists, with minor bands of felsitic, silicious and agglomerate schists. Traced still farther east through Crow-duck Lake and Rush Bay, this same northern band of these schists is found in Ptarmigan Bay to be apparently confluent with the schists of the analogous band of the south side of the syncline. In this way the band of schists with which we are dealing would be convergent in three points, and the lines of outcrop have the shape of a curvilinear triangle, as in the diagram, General form of outcrop of schistose belt.

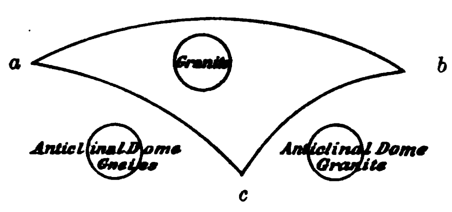

FIG. 13.—DIAGRAM ILLUSTRATING OUTCROP OF BAND OF SCHISTS.

where *a* and *b* are the points of convergence in the long axis of the synclinal fold, and *c* the convergence in the short axis between the anticlinal domes of the Canoe Lake granite and the Snow-shoe Bay

granitoid gneiss. This line of outcrop is thus simply the exposed edge of a basin or trough, in which lies the hornblendic and trappean schists through which protrudes the Indian Bay granite mass.

Description of Section E-F.

The section indicated on the map by the line E–F as traversing the Keewatin belt in a direction approximately parallel to its eastern limit, is of interest in showing the sequence and attitude of the strata on either side of the Yellow Girl granite mass, in its southern part; and in cutting the alternate, dove-tailed tongues of hornblende-schist and granitoid gneiss, in its northern part. The sequence of the rocks encountered in going north, across the strike, from the contact of the basal member of the series with the granitoid gneiss of White-fish Bay, is identical with that of the type section C–D, in the corresponding places, to within a short distance of the Yellow Girl granite mass. That is to say the hornblende-schists are followed by a group of mica-schists and micaceous slates, which are in turn followed by a band of hornblende-schists and traps and these again by agglomerate-schists.

Subdivision of basal group.

The basal group, which lies in contact with the gneisses, appears to be here susceptable of a threefold subdivision, viz., into (*a*) a sub-group of black, compact, hard hornblende-schists; (*b*) a great thickness of altered traps, more or less schistose as a rule, but often quite massive, constituting a second sub-group in ascending order, and (*c*) a sub-group of fissile green hornblendic and chloritic schists. In these three sub-groups we appear to have separated out in definite order, the rocks which usually are so intimately mixed in this group elsewhere; though the blacker and harder varieties of the hornblende-schists are apparently mostly confined to the neighborhood of the granitoid gneisses.

The general section, with the approximate thickness of the different members of the series, is here as follows:—

			FEET.
5.	Small, ill-defined bands of green schist, trap, mica-schist and agglomerate-schist		2,000
4.	Agglomerate-schists		800
3.	Hornblende-schists and traps		1,300
2.	Mica-schists and micaceous slates		4,700
1.	(*c*) Very fissile hornblendic and chloritic schists	3,800 feet	
	(*b*) Altered traps	4,200 "	
	(*a*) Black hornblende-schists	2,500 "	
			10,500
	Total thickness between granitoid gneiss and intrusive granite mass		19,300

The sub-divisions 1 to 4 present the same sequence as the section C–D, starting from the same line of contact about nine miles to the west.

The attitude of the rocks from 1 to 5 is that of continuous northerly-dipping series, at high angles, away from the granitoid gneiss. The brecciated character of the contact of the hornblende-schist with the granitoid gneiss, has already been described.

In approaching the Yellow Girl granite mass from the south, the rocks appear to dip under the granite. When the actual contact is arrived at, however, there is sufficient exposure in certain places to shew that the beds really stand on edge on the granite with which they are more or less mixed after the fashion of a breccia. What is true of the strata at the immediate contact is probably indicative of the relations to the granite of those strata which outcrop on the surface at some distance from the granite, and I have therefore represented the latter as standing on edge on the granite in the section. **Contact with Yellow Girl granite to south.**

On the north side of Yellow Girl granite mass the rocks dip away from the intrusion at high angles to the north. The section gives us an apparently ascending sequence as we go northward from the granite. There is crossed in succession a band each of mica-schist, hornblende-schist, grey compact felsite-schist and agglomerate-schist, and then we come upon the extensive development of hornblende-schists and altered traps which are in contact with the granitoid gneisses on the north-eastern confines of the belt, and are therefore regarded as basal. The second band away from the granite appears to be stratigraphically the same as this basal group, so that we have, in the neighborhood of the intrusion, a thickness of mica-schists lower than the formation which is usually basal. But these same mica-schists are also apparently the stratigraphical equivalent of the micaceous slates of the shore north of Yellow Girl, which are evidently higher than the hornblendic-schists. Hence it is very probable that the mica-schists which dip under the hornblende-schists on the section south of Witch Bay are in a locally inverted position, due to the disturbance caused by the intrusion of the granite, and that they with the micaceous slates and argillites of the shore north of Yellow Girl are on a horizon higher than the hornblende-schists. **Rocks north of the granite.**

The basal group of schistose hornblende-rocks and altered traps is that which prevails to the exclusion of almost all other rocks throughout the north-eastern portion of the belt, which in this direction presents a serrated line of contact with the Laurentian gneiss, and sends out tongues apparently of a synclinal character into the gneissic area. Two of these tongues are cut by the line of section. The nature of the contact with the gneiss which is presented in the first of these, that at Pine Portage, has been alluded to in the description of the general contact features of the belt. The second tongue crosses the narrows of Black Sturgeon Lake, which affords a good natural section across the strike. The rocks **Projecting tongues of basal members.**

are chiefly hornblende-schists and display a synclinal structure, the dip on either side of the belt being inward, away from the gneiss, although at high angles.

Surface Distribution of the Keewatin Rocks.

Relative surface importance of various members. Having now, by the consideration of these sections, indicated what appears to be the general structure of the belt, and the relations of the different groups of rocks which make up the whole series, I may refer briefly to the surface distribution of these groups so far as the character of the country renders the determination of this possible. The hornblende-schists and traps, which constitute the basal group of the series are the most extensively distributed of what remains to be seen at the present surface of the original Keewatin belt. This appears to be due partly to the more extensive removal by denudation of the upper members of the series, and partly to the fact that the latter were not laid down with that uniformity of distribution throughout the original trough, which seems to have been characteristic of the basal group. The next most prevalent rocks are the agglomerate-schists, which, as seen in one typical section C–D, occupy the second place in the ascening series; and last, though not differing much in this respect from the agglomerates, come the mica- and hydromica-schists and slates which are apparently at the top of the series as a general rule.

Subdivision into districts. The distribution of the rocks about the outer edge of the belt having been indicated in the chapter on its contact with the surrounding gneisses, it will only be necessary to speak now of the rocks forming the inner part of the area. For this purpose it is convenient to consider the area in districts which are naturally more or less distinct from each other. These are as follows:—

1. District of Rat Portage and Big Stone Bay.
2. " Ptarmigan Bay.
3. " Shoal Lake.
4. " the Western Peninsula.
5. " the Eastern Peninsula.
6. " the Islands.

The Rat Portage and Big Stone Bay District.

The piers of the bridge by which the Canadian Pacific railway crosses the Winnipeg River, just above Hebe's Fall, rest upon traprock. This is but one exposure of an apparently continuous band of the same massive crystalline rock which runs for several miles

through the broader band of hornblende-schists, which is in contact to the north with the granitoid gneisses. This trappean band runs with the strike of the schists and was nowhere observed to be more than about fifteen chains wide. It is directly traceable in a series of ten or twelve satisfactory exposures for a distance of six miles, first along the ridge of rock that separates Darlington Bay from the Lake of the Woods and then beyond that into War-eagle Lake. When it crosses the railway track near the west end of Darlington Bay it is seen in the railway cutting to be very largely serpentinized, and the same modification of it is also found on the shores of War-eagle Lake. On the shores of Clear-water Bay, near the portage to Deception, the same dark crystalline trap is observed as a band in the same black hornblende-schists, and in the line of strike of the band when last seen on War-eagle Lake. A massive black, crystaline, finer-grained trap was also observed in the tongue of hornblende-schists which crosses the narrows of Black Sturgeon Lake, which is simply the continuation of those which cross the Winnipeg River near Rat Portage. Thus the trap is found in the same band of schists on the same line of strike for a distance of twenty miles. For six miles at least it is almost certainly a continuous band and it seems probable that it is continuous throughout the entire distance between its extreme known exposures. This rock appears to merge directly into the hornblende-schists which it traverses. In a few places it is possible to trace the transition in the texture of the rock from step to step, first as a tendency of the crystals to arrangement in a direction parallel to the strike of the schists without loss of granular texture; then, as a more decided parallelism, accompanied by a partial obscuration of the granular structure due apparently to a squeezing or pulling of the rock; and finally the assumption of a definite schistose structure, in which the original granular texture of the rock has been obliterated. In other places, as near the entrance to the tunnel on Tunnel Island, the contact of the trap and hornblende-schists does not present this transition, but is associated with the development of a somewhat ill-defined, intermediate border, or selvage, of very soft steatitic schist. Beyond its striking contact, as a massive rock, to the easily cleaving schists, I observed no breccia formation or dyke-like off-shoots, or other evidence indicative of an intrusive origin, and I am induced by its extensive line of outcrop in a line of strike coincident with that of the schists and that of their contact with the gneiss, and by its transitional passage with the schists themselves, to believe that it is an ancient trappean flow interbedded with the schists and coeval with them.

Important trap intercalation.

It seems further possible that this trap may be the original form of the whole band of hornblende-schists, and is revealed to us simply as

a remnant of the rock from which they have been derived under the combined influence of pressure and uralitic transformation of the chief constituent minerals.

Section contrasting with typical one.

The natural section afforded by the shore-line southward from the contact with the Laurentian gneiss at Hebe's Fall, shews the sequence of the strata in interesting contrast to that given by the section C–D. The basal group of hornblende-schist and trap, which dips northward under the gneiss at angles varying from 60° to 75°, has a thickness of about 1,500 feet. The character of the schist is by no means strictly uniform throughout this thickness. In some places it is very quartzose, hard and slaty, as in the rock-cutting nearest the town of Rat Portage; in others it is softer, more hornblendic and greener in color, and characterized by the development of asbestus along planes of apparent slickensiding, which are roughly parallel with the planes of rock cleavage; in other places the schists shew the presence of considerable quantities of brownish-black mica in very fine scales, so that they would here be better described as micaceo-hornblende-schists. Following these hornblende-schists in ascending order is a breadth of about half a mile of mica-schists, mostly very quartzose, and merging, by the addition of feldspar, into gray, finely laminated gneissic schists, or gneisses. This group represents a thickness of approximately 2,500 feet of strata. The rocks dip continuously to the north at angles rarely, if ever, lower than 75°. In places they are intensely crumpled, as if there had been a strong doubling-up pressure acting in a direction parallel to the strike, in addition to the ordinary transverse pressure. Beyond the contrast in the lithological character of the rocks, there is no evidence of a stratigraphical break between the hornblende-schists and this superimposed group of mica-schists and finely laminated gray gneisses, the latter following the former in perfectly conformable sequence. These schists underlie a large portion of the town of Rat Portage, and are fairly well exposed on the shore as far southward as the creek which drains into the lake at the Rainy Lake Lumbering Co.'s mill. They are also well exposed on the railway behind the town in various cuts and natural exposures. Westward of Rat Portage they occupy the northern end of Coney Island, and form the south shore of Tunnel Island and of the ridge which separates the Lake of the Woods from Darlington Bay. A couple of chains to the south of the Rainy Lake Lumbering Co.'s mill, at the mouth of the creek, this group of micaceous and gneissic schists is in contact with a breadth of a quarter of a mile of bedded traps, hornblendic and chloritic schists, representing a thickness of about 1,300 feet. These rocks run across Coney Island, and occur on other islands to the west of it as far as the west shore, where they are

Rocks at Rat Portage.

found in contact with the lower mica-schist band, just as they are at the mill near Rat Portage. At the Coney Island Narrows the group is followed by a thickness of probably 1,500 feet of agglomerate-schists, the clastic nature of which has been determined by microscopic examination (p. 53 C C.)

Rocks near Devil's Gap. These agglomerate-schists are extensively developed on the south side of Coney Island, but they appear to be essentially a lenticular band, since they neither occur on the railway in the line of strike to the north-east nor westward on the west shore of the bay. They are probably the representatives of the enormous development of agglomerate-schists which occupy the north shore of Clear-water Bay. Following the agglomerate-schists, on the shore-line between Rat Portage and the Devil's Gap, is a thickness of about 2,000 feet of hornblende-schists of a comparatively black and slaty aspect. These have a continuous southerly dip, although the strike swings around from N. 80° E. to N. 55° E. Between this band and the Devil's Gap the rocks are greener hornblendic schists and schistose traps, both often quite chloritic. Intermixed with these are occasional small bands of mica-schists and slates, whose relations to them, whether as intercalated beds or as pinched-in folds, are quite undefined. The strikes of the rocks here twist about somewhat erratically from N. 55° E. to S. 75° E., and the exposures are not such as to allow of these being traced out in detail. A small patch of these slates, associated with some felspathic schists, probably clastic, occur at the entrance to the Devil's Gap, on the west side. They have a strike of N. 80° E., and dip vertically. South of these the section through the Devil's Gap shews only massive, fine-grained, dark-green rocks, a typical specimen of which has been determined by Mr. Bayley to be an altered trap. These rocks are most massive at the north end of the Gap, and in going southward across the strike, which, as far as can be determined, is about N. 80° E., they gradually assume a roughly schistose character, and finally, at the south end of the Gap, appear to merge, across the strike, into chloritic schists.

Trap dyke. These chloritic schists are cut on the east side of the south end of the Gap by an intrusive mass of hard, compact, moderately fine-grained, fresh trap, which is of much later date than the other rocks of the vicinity. The presence of this trap in the line of the long, straight, fissure-like water-route which runs from the Winnipeg River southward by way of Coney Island Narrows and the Devil's Gap, suggests that that route lies in a line of faulting. There is, however, little real evidence in support of such a supposition. Southward and eastward from the Devil's Gap, the main shore of the lake is made up almost entirely of rocks similar to those in the Gap. They appear to

be to a large extent altered traps, of massive aspect and little or no indication of bedding, associated with more or less chloritic hornblende-schists and smaller, vein-like bands of dark, glossy, green schists, with a peculiar crumpled cleavage, which appear in most cases to be altogether chloritic, although sometimes they are largely epidotic, when they show a greenish-yellow colour in patches. These bands of dark-green, crumpled, chloritic schists vary in width, as a rule, from two to twenty yards, and traverse the more massive compact rocks in such a way that I am induced to consider them as derived by processes of mineralogical decomposition from the latter. They merge directly into the rocks they traverse, and would appear to have been developed from them by aqueous percolation along planes of separation, which are either the partings of an original bedding, or are fissures of subsequent date. These chloritic bands are often characterised by the presence of quartz veins and stringers, and occasional natural vertical sections shew the quartz veins to have an irregular zig-zag course through the schists. The presence of these quartz veins clearly points to these chloritic bands having been channels of ready percolation, and although the veins are not present in a very large number of those observed, yet, considering their passage into the adjacent rock on either side, and their limited width, it appears altogether probable that they are not bedded strata, but have originated in the way suggested.

Mode of production of chloritic bands.

Hydromica-schists.

Beyond the hornblende-trap and chloritic schists, the only other rocks met with between the Devil's Gap and Pine Point are some narrow bands of hydromica-schist and a narrow band of mica-schist. The hydromica-schists appear on either side of the peninsula which terminates in Brulé Point. On the west side they appear as comparatively fresh, whitish to nacreous, very fissile sericite-schists, having a strike of N. 64° E. and a dip to the north-west at high angles. Those on the west side of the peninsula skirt its east shore with a strike of N. 54° E. and dip to the south-east. These schists, though somewhat more decomposed and chloritic than those on the west side, are doubtless the same rocks, and the divergence of their dip is suggestive of an anticlinal structure, the axis of which is coincident with the middle line through the peninsula. These narrow bands, it is to be observed, are but the tapering northward extensions of the large development of hydromica-schists which prevails in the Northern Peninsula and on Scotty, Middle and Hay Islands. The band of mica-schists referred to occurs on the east side of Bald Indian Bay, near the Quarry Island gneiss. The band cannot be traced for any distance, and has no apparent connection with similar rocks elsewhere.

On the east side of Pine Point the same massive green schists prevail as to the west. On the east side of Pine Portage Bay, however, there is an interesting occurrence of a considerable thickness of fissile, dark-green hornblende-schists. These occupy the whole breadth of Heenan Point, and extend from its extremity to beyond the bottom of Pine Portage Bay. Their general strike varies from N. 15° E. to N. 30° E., and is practically identical with the direction of the long axis of Heenan Point. The dip is about vertical. They cross Big-stone Bay, and form the rock of the opposing Needle Point on Hay Island. At the base of Needle Point the band appears to double on itself, since the same schists appear farther east on the north side of Hay Island with a strike which converges rapidly towards that of the schists of Needle Point. The dip of the schists of Needle Point is eastward, and that of those which converge upon them is to the north-west, so that the attitude of these two converging bands of similar schists presents all the aspects of a syncline. The schists which thus occupy Heenan Point and Needle Point are essentially hornblendic, but very much decomposed, and thus characterized by the presence of large quantities of chloritic material and the segregation of calcite or or dolomite and quartz. The calcite resulting from the decomposition of the silicate has often separated in such a way as to form an almost gneissic interlamination with the hornblendic and chloritic constituents of the rock, presenting a distinct alternate banding of white and green. The quartz has segregated in irregular stringers, and is not infrequently characterized by the presence of beautiful radiating bunches of black tourmaline needles. **Hornblendic schists.**

These schists in their general characters resemble closely those which have been described as the uppermost sub-group (*c*) of the basal group of hornblendic schists and traps cut by the Section E–F between White-fish Bay and Yellow Girl Bay; and they appear to occupy an analagous place stratigraphically with reference to the more massive lower members of the group. Their relatively higher position in the group of hornblende-schists and traps so extensively developed in the Big-stone Bay district, is indicated by their lying in the central portion of the Pine Portage syncline. Their place in the heart of the syncline is interesting in a consideration of the origin of schistose structure or rock cleavage in general. If, as seems to be generally true, schistose structure is due to the influence of pressure upon rocks, we should naturally expect to find the rocks most schistose in those positions where we have reason to believe the greatest pressure was exerted. Now, in the cores of synclinal and anticlinal folds the pressure must have been much greater than that exerted on their flanks, by reason of the leverage afforded by the rocks themselves. It is, **Origin of schistose structure.**

therefore, an interesting confirmation of the theory of the causal relations of pressure and schistosity to find, as in the present instance, the more fissile rocks in the heart of a synclinal fold.

Rocks of Big-stone Bay. The shores and islands of Big-stone Bay east of Needle and Heenan Points are almost entirely composed of massive greenish-black, feebly schistose hornblende-rocks, such as that microscopically described as Section 13, and more or less schistose altered traps, with not a few of those narrow vein-like bands of crumpled chloritic schists already alluded to. These rocks form the greater portion of Hay Island, and the shores of the lake around to the base of Pipe-stone Point. Their distribution is limited to the south-west, however, by their coming in contact on the south side of Hay Island and on Middle Island with a higher group of hydromicaceous magnesian and chloritic schists, which curve sharply around the more massive rocks of Hay Island, as if they formed the flanks of a truncated anticline. The strike of these schists on the south side of Hay and Middle Islands varies from due east to S. 80° E., and they form a band which appears to run through Pipe-stone Point, as a narrow tapering infold in the massive green rocks. The average strike of the same schists on Middle Island is about N. 40° E., so that the general trends of the two spurs of the bifurcation which thus embraces the rocks of Hay Island, converge at the south-west corner of Middle Island. From this point the rocks have a common strike across the lake of west-south-west.

Stratigraphical difficulties. The mapping of the distribution of the rocks and the general relations of the hydromica group to the hornblendic group as a higher member of the series, point very distinctly to a anticlinal structure. The dip of the schists in the two branches of the bifurcation, however, although always at high angles, is that of a syncline. It is a difficult matter to reconcile this synclinal dip with the other anticlinal conditions that appear to hold, unless we call to our aid the assumption of a marked unconformity between the hornblendic rocks of Hay Island and the hydromicaceous group of schists. The more massive character of the rocks of Hay Island and the Hades Islands renders the determination of their trend and dip (if they be stratified at all), very unsatisfactory and in themselves afford little evidence bearing upon the question of the conformability or the reverse of the two groups. Such traces of stratification as are observable, however, appear to indicate that the planes of the latter are coincident with those of the overlying group of hydromicaceous magnesian and chloritic schists. These fissile schists pass by gradations on the west side of Middle Island, into more massive agglomerate-schists, which here present a considerable breadth, and on Scotty Island run in two parallel bands apparently interbedded with the hydromica-schists.

The north end of Scotty Island is occupied by green hornblendic, trappean and chloritic schists. On the south-west of Scotty Island the schists are cut transversely by a large dyke of granular trap. This dyke is in the line of strike of, and probably identical with, a large dyke of similar trap, 180 feet wide, which cuts the schists of Thompson Island across its entire breadth. This dyke is probably of the same age as that at the south end of the Devil's Gap. On the south-east side of Thompson Island the dyke was observed to be fine-grained in the neighborhood of its contact with the schists and to become very much coarser grained towards the centre, where, also, a certain proportion of quartz was detected which was not visible in the same rock nearer the dyke walls. Trap dyke.

An inference can be drawn, as to the condition of the rock as a magma at the time of its injection, from the fact, that those portions of the schist wall, which were broken off and formed, with the intruded rock, a contact breccia, have not travelled far through the magma from their original places of rest. Instances, such as that illustrated in the accompanying figure, where blocks of included schist are seen to Contact phenomena of trap.

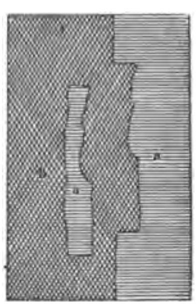

FIG. 14.—CONTACT OF DYKE WITH SCHIST WALLS, THOMPSON ISLAND.

have moved only a short distance from their origin, indicate that the magma axis must have been comparatively thick and viscid.

Another dyke of the same trap was found cutting the schists on the main shore a little over a mile and a-half west of Point Aylmer.

In the natural section presented by the west shore of Rat Portage Bay from Keewatin to Point Aylmer, the higher members of the series are much more strongly represented than on the opposite shore from Rat Portage to the bottom of Big-stone Bay. Following the band of micaceous and gray gneissic schists, which have been alluded to as occurring in the north-west corner of the bay, in the same relative position as the same schist at Rat Portage, there is to the south-west a band of green hornblendic and trappean schists three-eighths of a mile Rocks of Rat Portage Bay.

wide. These are followed by a breadth of half a mile of micaceous and gneissic schists comprising a narrow band of black carbonaceous schists, the whole having a general strike of about N. 80° E. or N. 85° E. and a more or less vertical dip. To the south of these the shore is occupied for a mile and a-quarter, in a straight line, by green hornblendic and trappean schists. The strike of these is from S. 80° E. to S. 75° E. and the dip varies but little from the vertical either way. In the islands off shore these schists appear to pass into agglomerate-schists, which are probably the continuation of the lenticular band of agglomerates that presents its strongest development at Coney Island Narrows and on the south side of Coney Island. The next mile and three-quarters of this shore, measured in a direct line, is occupied almost altogether by soft, fissile, green to gray and glossy hydromica and chloritic schists. The strike of these schists varies from N. 85° E. to S. 75° E., and the dip, when not vertical, is to the north at high angles. They appear at the north end of Poplar Bay, and cross the peninsula with the same general breadth to Clear-water Bay on the west side. The shore to the east of these fissile schists as far as Dispute Point and the opposite shore of Tangle Island, together with the shores and islands about the entrance to Poplar Bay, between Dispute Point and Point Aylmer, are of rather massive green schists, through which, in their extension south-westward, a granite boss protrudes. In the neighborhood of Dispute Point there appear, running through these schists, bands of a ferruginous dolomite varying from a foot or so to twenty feet in width. This and other dolomites, as I have stated elsewhere, appear to be segregated masses and not interstratified beds. On the north side of Tangle Island and the south-east end of Treaty Island there are bands of micaceous schists which, since they are in the same line of strike as the hydromicaceous and micaceous schists of the main shore, are probably the representatives of the latter diminished in volume in this direction. The greater part of Treaty Island is composed of the same massive green rocks as are exposed in the Devil's Gap, and described as altered traps, with subordinate bands of chloritic schists. Port Aylmer is composed of coarse agglomerate-schists. The east and west sides of Thompson Island are occupied by very fissile hydromica- and chlorite-schists, while through its central portion there appears to run a band of massive green schists of the altered trap variety.

The Ptarmigan Bay District.

The predominating rocks in the Ptarmigan Bay District are agglomerate-schists, hydromicaceous and chloritic schists and micaceous slates.

Clear-water Bay is eroded out of a wide band of the first of these rocks, which is well exposed along nearly the whole of its northern shore and a considerable part of its southern. These schists at the east end of the bay (*i. e.*, part north of the entrance to White Partridge Bay), are of the character of greenstone-agglomerates. Westward of this, however, they merge into micaceous and finely laminated, fine-grained, grey, gneissic, agglomerate-schists, and towards McCallum Point the agglomerate characters become so feeble that the schists are often, in bands, simply mica-schist. The continuation of this band on the shore opposite McCallum's Point is represented by schists which are mostly micaceous and show little or none of the characteristic appearance of the agglomerates, though obviously of the same stratigraphical formation. The agglomerates on the south side of the bay, which form so large a part of Zig-zag Point, are less micaceous and more of the character of greenstones than on the north side, merging into bands of hornblendic and chloritic schists on the one hand and into felsitic schists on the other. Preponderating rocks.

The basal bands of hornblende- and trap-schists described as occupying a large part of the west side of Rat Portage Bay, does not come through to Clear-water Bay, but thins off rapidly to a wedge between the Clear-water Bay agglomerates and the next band to the south, of micaceous and hydromicaceous schists and slates, which are thus, by the disappearance of the intermediate band, allowed to come in contact. These micaceous and hydromicaceous schists cross the peninsula from the west shore of Rat Portage Bay, and form the prevailing rock on the shores of White Partridge Bay, which affords almost continuous exposures of them throughout its length. They occupy the greater part of the northern peninsula and Cork-screw Island, which they cross in a broad band with a strike varying from N. 80° E. to S. 80° E. The dip, as a rule, varies but little from the vertical. In the natural section afforded by the channel to the east side of Cork-screw Island, however, the dip is seen in the northern portion of the band to be to the north, while southward, towards Spruce Point, it inclines to the south, giving the strata the aspect of an anticlinal fold. Those portions of the band which occupy the shores of White Partridge Bay are more micaceous and slaty than the schists farther southward, which are chiefly glossy, grey to nacreous hydromica-schists, with bands of soft, fissile, green, chloritic schists. The north side of the east-and-west trending portion of the channel, which lies east of Cork-screw Island, exposes a considerable extent of an apparently lenticular band of agglomerate-schists which crosses the channel to Cork-screw Island, but does not appear on its west side. This lenticular band of agglomerate-schists is to be regarded stratigraphically as an integral portion

Hornblendic rocks and trap-schists.

Rocks on White Partridge Bay, etc.

of the hydromicaceous group of schists rather than as the crest of a return fold of the Clear-water Bay agglomerates. Westward of Cork-screw Island the hydromicaceous schists continue across Ptarmigan Bay with the same general strike, but are seen on the islands of the bay and on the south side of Zig-zag Point to be strongly interbanded with hornblendic, altered trappean and chloritic schists. At the west end of Ptarmigan Bay these schists bifurcate and form two diverging bands, one trending through Echo Bay and then curving southward around the Canoe Lake granite mass, and the other, striking westward, is traceable by excellent exposures along Rush Bay into Crow-duck Lake. In Crow-duck Lake the schists are frequently intercalated with narrow bands of agglomerate-schists, and often pass into hard, whitish, felsitic schists. Associated with the hydromicaceous group of schists, although not altogether confined to them, are a number of small but very interesting bands of carbonaceous schists. The general character of these has already been described, but the localities where these bands are exposed, on the shores of Ptarmigan Bay, may be noted. On the south side of Wood-chuck Bay, (the western end of Clear-water Bay), at a point about a mile west of Mud Portage, the agglomerate-schists, which are there the prevailing rock, are interbedded with small bands of fissile micaceous and hydromicaceous schists. In one of these latter bands is a small thickness of black carbonaceous schists. It is difficult to say what the precise thickness is, as the shore makes but a small angle with the strike at the particular place of exposure, but it does not appear to exceed fifteen or twenty feet. The strike is N. 80° E. and the dip north at very high angles.

Carbonaceous schists.

Two miles and a-half east of Mud Portage, on the north side of Zig-zag Point, there occurs another smaller band of the same schists under similar conditions. The strike is about the same as in the last case, and the dip is vertical. Another band of black carbonaceous schists was observed interbedded with a fine-grained, grey, apparently clastic slate, on the north side of Cork-screw Island, near its north-eastern extremity. The slates are associated with mica-schists of a black, slaty character, the general strike being S. 80° E. and the dip not appreciably varying from the vertical. On the south side of Zig-zag Point, about midway between Mud Portage and the extremity of the point, a band of carbonaceous schists, of small width, with a strike of N. 75° E. and north-westerly dip, occurs in black, slaty, micaceous schists. The same band has been exposed by prospectors three-quarters of a mile eastward along the line of strike. Half way between this and the extremity of Zig-zag Point another band, about twenty feet wide, outcrops on the shore with a strike of N. 65° E. and south-easterly dip, interbedded in schists similar to the last. This band may possibly be

identical with the last and lie in the return of a local synclinal fold. On the south-west end of Cork-screw Island, about half a mile north of the narrows between this and Copper Island, a bank of carbonaceous schists, not more than ten feet wide, runs through the hydromica-schists, into which, by a diminution of the proportion of carbonaceous matter, they merge on either side. The strike is S. 80° E. and dip north $< 80°$.

The only other feature of special prominence, revealed by an examination of the rocks along the tortuous shores of Ptarmigan Bay, is the development of a large band of agglomerate-schists in the vicinity of Ash Bay. In its general outlines this band is lenticular in shape, its maximum breadth lying in the line of section C–D. As may be seen by that section it is regarded as stratigraphically identical with the Clear-water Bay agglomerate-schist band. Westward of Ash Bay the band tapers off rapidly, interfolded with the underlying group of hornblende-schists and altered traps. Eastward it also tapers off somewhat abruptly, so far as can be judged from the islands of the bay, but is traceable in a more attenuated band to near the entrance to Ptarmigan Bay and is represented still further to the north-east by the agglomerate-schists of Hare and Wolf Islands.

Shoal Lake District.

The more interesting geological features of this part of the area have been described more or less at length in those parts of the report which deal with the confines of the area, the granite masses, and the line of section A–B, so that there remains little of importance to which attention should be directed. A few explanatory allusions may, however, be made to some of the features represented on the map, which have not hitherto been referred to.

Isolated patches of agglomerate-schists.

There occur on the shores and islands of Shoal Lake, a number of isolated patches of agglomerate-schists which appear in some cases to be the remnants of once continuous bands, now nearly altogether surrounded by denudation, and in others to be merely local developments of the formation, on horizons occupied as a rule by other rocks, into which it merges. The eastern extension of Cash Island is composed of a rather massive greenstone agglomerate-schist, no representative of which is found on the north shore of this lake in the continu-projection of the line of strike. Felix Island, about a mile to the north of this, is also composed of these agglomerate rocks.

Passage into trap-schists.

There are a number of patches of the same rocks in the neighborhood of the Indian Bay Narrows, which merge into altered trap-schists, of a massive character. Although represented on the map in different

colours from the trap-schists, they appear to be of the same stratigraphical formation as the latter. A number of the islands opposite the mouth of Hell-diver Bay are composed of agglomerate-schists which are probably the representatives of the band which runs from Crow Rock Channel across to the south end of Labyrinth Bay and westward. The shores of the Shoal Lake Narrows and Labyrinth Bay are interesting in presenting the most extensive exposures of serpentine rocks that have been observed in the region. They are intimately associated with more or less schistose altered traps, which are extremely calcareous and effervesce freely with dilute acid. It would be difficult to map the exact distribution of these serpentine rocks without making a very detailed examination of the ground, and their relations to the surrounding rocks. Although they do not appear as dykes or afford much satisfactory evidence of irruptive origin, it is probable that such is their character, and that they are the altered representatives of intrusions of olivine-bearing rocks of later date than the Keewatin series.

Serpentine rocks.

Association.

The association of the very calcareous trap-schists and the serpentines is interesting, since both are profoundly altered rocks, and the result of mineralogical disintegration and re-composition along different lines of chemical relation in rocks of orignally different constitution, although the former is an essential part of the Keewatin series, and the latter probably intrusive through the series.

Schists on west side Shoal Lake

The group of schists in contact with the granitoid gneiss on the west side of Shoal Lake, require perhaps a few words of description supplementary to the map. These schists have a strongly marked stratified aspect, and are composed for the most part of quartz and mica. In the immediate vicinity of the granitoid gneiss, however, there is present a considerable proportion of black hornblende, and the rock presents, to a feebly-marked extend an agglomerate appearance. In many places there is a considerable proportion of feldspar present in the rocks where they pass into gray, fine-grained, evenly laminated gneisses. The micaceous and quartzose minerals, however, preponderate, and give character to the rocks of the group as a whole. Towards the eastern margin of the band, in the vicinity of Rabbit Point, there are interstratifications of green hornblendic schists, and on the south side of Gull Bay, the band is seen to be followed conformably to the eastward by a breadth of green hornblendic and altered trap-schists. A mile or so farther southward these are in contact, on the extreme east of the shore, with a band of black, slaty mica-schists, of unknown width. Beyond Berry Point there are no exposures at the south end of the lake, except a boss of diorite that projects through the sand about a mile east of the Hay River.

The Western Peninsula.

The general character and relation of the strata which occupy the northern portion of the Western Peninsula have been given in the account of the line of section C–D, and the same has been done for the rocks in the vicinity of Deadman Portage, in the account of the granite, and of the section A–B. Southward toward the North-west Angle Inlet, the rocks within the interior of the peninsula are more or less unexposed or unaccessible, so that their actual distribution has not been satisfactorily determined, and the mapping is only such as appears most probable from the observations made along the shores.

The probable stratigraphical identity of the more or less gneissic mica-schists, which dip away from an undefined extent of granitoid gneiss, on the south-east side of Shoal Lake, with the mica-schist dipping away from the granitoid gneisses, at the mouth of the North-west Angle Inlet, has been pointed out. Following these schists along the shore to the north of the mouth of the inlet is a band of hornblende-schists, nearly three-quarters of a mile in breadth, which passes in its central part into agglomerate-schists. The dip of these schists is at first coincident with the mica-schists to the south of them, but within a short distance from the contact the dip changes and inclines to the south, but as in both directions it is at angles higher than 75°, little can be inferred from the change as to the structure of the strata. The general strike of the schists along the shore is from S. 70° W. to due west, so that the projection of this band westward in the line of strike would cause it to converge with the central band of hornblende-schists that occupies the axis of the peninsula. This convergence of the strike, indicating a curving around of the axial band of hornblende-schists, so as to cause them to appear on this shore, is quite in harmony with the similar convergence of the mica-schists which lie between the hornblende-schists and the granitoid gneiss. Along the same shore the hornblende-schist band is followed by a band, three-quarters of a mile wide, of southward-dipping agglomerate-schists. These are mostly micaceous and quartzose, and pass on their northern margin directly into gray, gneissic, mica-schists. This band, in accordance with what appears to be the relations of the strata to the south of it, can only be the return of the band of agglomerate-schists, which is so largely developed on the north side of Monument Bay, as a continuation of the band which runs from Wiley Bay, and strikes in towards the centre of the peninsula, at the west end of Monument Bay. Finally, the great breadth of hornblende-schist and altered traps which occupies the south side of Monument Bay and the shore to the south of it, would appear to be a synclinal duplication of the band of similar rocks, which trends along the east

Gneissic mica-schists.

Hornblende- and agglomerate-schists.

Synclinal duplication on Monument Bay

side of the peninsula, and is chiefly developed in the islands between the Big Narrows Island and main shore. This band is in more or less direct continuity, as will be seen from the map, with the north half of the schists on the south side of Monument Bay, so that their southern half would be the equivalent of the band of the same rocks cut by the section C–D, about a mile south of Big Narrows Island, according to the interpretation placed upon the attitude of the strata along that line.

The shores of the peninsula, from the bottom of Shoal Lake on the one side, and the North-west Angle Inlet on the other, north to its extremity at Brulé Point, afford excellent and continuous exposures of the rocks, so that the map itself and the observations recorded upon it, give the most concise account of the natural sections of the strata of which it is composed.

The Eastern Peninsula.

Anticlinal structure. The anticlinal character of the Eastern Peninsula is well illustrated in a transverse section taken across the peninsula and islands in the vicinity of Bottle Bay. In the axial line of the peninsula is an elongated mass of irruptive granite, and on either side of this, the sequence of the rocks is the same, and they dip away from the irruption at higher angles. On the north side the succession is as follows:—

1. Massive green schists, hornblendic and altered traps.	Dip north.
2. Grey felsitic schists, merging into agglomerate to the north.	
3. Agglomerate-schist.	

On the south side we have:—

1. Massive green schists, as before.	Dip south.
2. Yellowish felsitic schists with clear quartz grains, merging into agglomerates to the north.	
3. Agglomerate-schists.	

Intercalated clay-slates. Farther south, between this line of section and Yellow Girl Point, a a considerable thickness of more or less micaceous clay-slate intervenes between the green schists and the felsitic schists, so largely developed on Shore Island. There same slates, often quite massive and devoid of slaty cleavage, but nevertheless undoubted argilites, occur near the granite at Yellow Girl Point, and at the immediate contact appear as glossy-black micaceous slates, the differentiation being due, doubtless, to contact metamorphism. These slates are probably stratigraphically identical with the band of mica-schists observed in contact with the same granite mass on the bush traverse from the east end of Witch Bay. Here the mica-schists dip under the hornblende-schists, but owing to the disturbance due to the irruption, this is probably a locally inverted

dip, and the schists are really superimposed upon the green hornblendic schists, constituting with the slates of the shore north of Yellow Girl Point, a development of partially altered sediments, which would thus occupy the same horizon as the similar micaceous schists and clay-slate of the east end of Yellow Girl Bay, and the more quartzose mica-schists exposed along the greater part of the Adams River. The felsitic schists of Shore Island, and the bay to the north of Yellow Girl Point, appear to lie in a trough of these slates.

The other more prominent geological featnres of the peninsula have been already touched upon in former parts of the report.

The Islands.

Connection established between peninsulas by the islands.

Among the more interesting stratigraphical features revealed by the exposures on the islands of the lake, is the connection that is established between the anticlines of the Eastern and Western Peninsulas by the belt of islands extending from French Narrows to Crow Rock Channel. This connection will be best understood by an examination of the map. The dip of the rocks on these islands varies but little from the vertical, and ordinary anticlinal divergence of the dip is not often observable, so that taken by themselves the structural relations of the strata composing these islands is not very apparent. Taken, however, in connection with the structure of the peninsulas, between which they form a chain of connection, as it were, those relations become plain. Generally speaking, the central portions of the islands are rather massive hornblendic schists and altered traps, through which have been irrupted a series of granites or micro-granites, while to both the north and south of this median band lie broad belts of agglomerate-schists. This relationship is the same as that on the main shore at Crow Rock Channel and at the extremity of the Eastern Peninsula, and as the islands are in the same curved line of strike as the rocks at those points, their geological structure is undoubtedly the same. The agglomerate-schists on the north side of this belt of islands, form the connecting link between the agglomerate-schists of Crow Rock Channel and those of Andrew Bay, so that these rocks may be said to extend in a continuous band from the Shoal Lake Narrows to the east end of Witch Bay, a distance of over twenty-five miles. The general strike of this band is a curve concave to the south, the radius of the curve being about thirty miles.

The agglomerate-schists of the south side of Crow Rock Island, Allie Island and numerous other islands indicate clearly the continuation of the band of similar rocks which runs north-eastward from Monument Bay, past Portage Bay to Wiley Bay on the main

shore. This band trends in an almost semicircular curve from Portage Bay to within half a mile of Yellow Girl Point, the curve being as before concave to the south, with a radius of about fifteen miles. On Fog Island, near Yellow Girl Point, this band of agglomerate-schists is seen to turn on itself and trend off westward in a direction diverging from the previous strike by 60.° The strike can be traced bending through this angle and the dip of the whole is synclinal so that we have here undoubtedly the end of a synclinal fold. The southern spur of the syncline cannot be traced far, since it runs under the waters of the lake.

Glacial Phenomena.*

General character of glaciation.

The Lake of the Woods region is profoundly glaciated. Indeed, it may be correctly regarded, as has been previously stated, as a partially flooded region of *roches moutonnées*. Everywhere the rocks display unmistakable evidence of the polishing and grooving effects of the passage of detritus-laden ice over the surface of the country. The flow of the ice, as indicated by the direction of the groovings, has been from north-east to south-west. This, it is to be observed, is not strictly coincident with the strike of the rocks. This general or average strike of the rocks is more of an E. N. E. and W. S. W. direction, and as a matter of observation, it appears to be generally true that it is the strike of the rocks, rather than the direction of the ice flow, that has determined the direction of the long axes of the *roches moutonnées*. The direction of the ice flow from north-east to south-west is probably that of the general dip or slope of the surface of the country over which the ice passed, and this appears to have exerted a more powerful directional influence upon the moving ice than the trend of the ridges of the country. The *roches moutonnées* are, if we regard the surface of the Lake as a base of reference, of all sizes from mere rounded hummocks to large islands over one hundred feet high. They are best exposed on the northern aspects, while the southern is usually more or less concealed by heaps of drift, chiefly boulders, that appear to have been dropped by the ice immediately after its passage over the obstruction. This talus of boulders upon the southern slopes of the rounded rocks of the country is a feature of considerable constancy so far as observed. Northerly or north-easterly facing

Distribution of boulders and drift.

* As stated in the introductory portion of this report, the general character of the glaciation and distribution of the drift on the Lake of the Woods, has been pretty fully treated by Dr. G. M. Dawson. See Geology and Resources of the Forty-ninth Parallel, Chap. IX. and Quart. Journ. Geol. Soc., Nov., 1885.

shores are, as a rule, bold and rocky, while those facing the south present much more limited rock exposures and low bouldery beaches. The contrast is readily observable on many of the islands and channels of the lake. Of these may be cited by way of example Hay Island, whose northern aspect is abrupt and rocky, while on its south side it is characterized by considerable stretches of boulder-strewn shores. The same is true of Middle and Scotty Islands, which are more or less pointed to the north and have low shores on their south side: Boulders are far more abundant upon the north and south-west shores of the Eastern Peninsula than upon its northern shore, which is abrupt and rocky. The south and south-west shores of the Northern Peninsula are more or less strewn with drift. The south shores of Big Narrows Island, Falcon Island, Birch Island are all more or less strewn with boulders, which are almost entirely wanting upon their northern shores. The same contrast is observable in east-and-west trending bays and lakes. Crow-duck Lake has a precipitous south shore and a lower sloping more or less drift-covered northern shore. The peninsula which separates Indian Bay from Snow-shoe Bay is more rocky and abrupt on the north side than on the south, which is more or less strewn with drift except on the projecting points. The north shore of Long Bay is thickly strewn with boulders and the shore is low and sloping as a rule, while the south shore of the Bay is precipitous and rocky. Instances might be multiplied, but these will suffice to illustrate a principle that seems to prevail in the distribution of the drift.

Drift of northern part of lake.

The northern portion of the lake is characterized by a general absence of the finer kinds of drift, sand and clay deposits are rare, and the drift is composed almost entirely of more or less rounded fragments of rocks of Archæan origin. The largest boulders sometimes attain a size of fifteen feet cube, and from six to ten feet cube is not unfrequently met with. These larger boulders are usually angular and are composed of either granite or granitoid gneiss. The smaller boulders, those of an average diameter of a foot or less, are generally quite rounded. In the southern part of the lake the drift is of an essentially different character from that of the northern portion, both in the abundance of the finer kinds of drift of a sandy nature, and in the character of the erratic blocks themselves. In addition to the erratics of Archæan origin, fragments of a buff or cream-colored fossiliferous limestone of Cambro-Silurian or Silurian age, are more or less thickly strewn about its shores. Occasional small pebbles of this limestone are found in the northern part of the lake as far north as Rat Portage, in gravel deposits. But apart from such small fragments, these limestone erratics are a peculiar feature of the southern portion of the lake, a fact first observed by Dr. J. J. Bigsby. Dr. G. M. Dawson has

Drift of southern part of lake.

suggested a number of possible explanations of the occurrence of this limestone drift and its confinement to the southern portion of the lake. He conjectures the possible existence of a limestone floor for this portion of the lake, which may be now either concealed or may have been removed by glacial action; considers the possibility of the limestone being derived from the Hudson Bay area of fossiliferous rocks, and finally regards as the most probable explanation, a process of translation from the similar beds of the Red River valley, by means of floating ice at the close of the glacial epoch.

Origin of limestone drift. Recently discovered glacial striæ on the polished surface of the flat-lying rocks of the Red River valley which have a north-west and south-east course, as well as the prevalence of such striæ or groovings in eastern Minnesota, and the striation occasionally detected on the Lake of the Woods in a direction transverse to the general ice flow,* point to an ice stream of later date than the north-east and south-west moving glaciers, which probably set in from the high lands which bound the first prairie steppe to the west. This stream, coming down the valley of Lake Manitoba and Lake Winnipegosis from the east flanks of the elevations now represented by the Porcupine Hills and the Duck and Riding Mountains, would cross Manitoba in the direction indicated by the striation of the rocks at Stony Mountain †, at Stonewall ‡ and at Black Bear Island, Lake Winnipeg §.

The close similarity of the limestone drift of the southern portion of the Lake of the Woods with the bedded limestones of Manitoba, lends strong support to the explanation indicated by these glacial groovings.

The following is a record of the directions of the glacial groovings and striæ, so far as observed by myself and assistants, upon the Lake of the Woods and vicinity:—

List of Directions of Glacial Groovings and Striæ.

Bottom of Pine Portage Bay	S. 40° W.
Pine Portage Bay, east side	S. 35° W.
Heenan Point	S. 11° W.
Point Aylmer	S. 47° W.
"	S. 15° W.
Rat Portage Bay, west side	S. 27° W.
War-eagle Lake, south side	S. 55° W.

*See Geology and Resources of the Forty-ninth Parallel, p. 206.

† Manitoba Historical and Scientific Society Trans. No. 15, 1884-5. "Gleanings from outcrops of Silurian strata in the Red River valley by J. Hoyes Panton, M. A., pp. 7 and 8.

‡ Id. p. 11.

§ Id. Trans. No. 20, 1886, "Notes on the Geology of some islands in Lake Winnipeg" by J. Hoyes Panton, M. A., p. 5.

Small lake, north of Crow-duck Lake	S. 55° W.
Channel S. W. of Cork-screw Island	S. 40° W.
Island off north shore Cork-screw Island	S. 47° W.
" " " " "	S. 50° W.
Island west of last	S. 55° W.
Bay on west side of Cork-screw Island	S. 50° W.
Island east of Zig-zag Point	S. 52° W.
South side Zig-zag Point	S. 45° W.
Mud Portage Bay	S. 54° W.
Island in Ptarmigan Bay, south of Mud Portage	S. 55° W.
Island at mouth of Rush Bay	S. 52° W.
Island in Rush Bay	S. 57° W.
Echo Bay, west end	S. 54° W.
Island off S. W. end of Copper Island	S. 54° W.
Copper Island, south side	S. 42° W.
Cork-screw Island, south side	S. 52° W.
Island in Ptarmigan Bay, 2 miles west of Brulé Point	S. 50° W.
Ptarmigan Bay, south side	S. 50° W.
Island south of Brulé Point	S. 50° W.
Island, 1½ miles S. E. of Brulé Point	S. 45° W.
Shore, 1¼ miles south of Brulé Point	S. 45° W.
Fox Island, north shore	S. 42° W.
Wolf Island, S. E. side	S. 44° W.
Scotty Island	S. 45° W.
Small island off east side of Scotty Island	S. 35° W.
Largest of the Hades Islands, west side	S. 45° W.
Same island at another place	S. 45° W.
West side of Hay Island	S. 25° W.
" " to the north of last	S. 30° W.
Island off south shore of Middle Island	S. 30° W.
Extremity of Pipe-stone Point	S. 42° W.
Pipe-stone Point, near extremity, south side	S. 46° W.
" " east of last	S. 47° W.
" " north side	S. 43° W.
Island off north side of Pipe-stone Point	S. 40° W.
South shore, Witch Bay	S. 50° W.
" Witch Bay, ¾ mile farther west	S. 45° W.
" Witch Bay, ¼ mile west of last	S. 50° W.
" Andrew Bay	S. 50° W.
A mile and a-half east of French Narrows	S. 42° W.
Two miles S. E. of French Narrows	S. 30° W.
Shore, 2½ miles S. E. of French Narrows	S. 37° W.
Island half-way between French Narrows and Yellow Girl Point	S. 53° W.
Island 3¼ miles N. W. of Yellow Girl Point	S. 40° W.
Island south of Ferrier Island	S. 43° W.
South-west side of Shore Island	S. 45° W.
Half a mile S. E. of last	S. 45° W.
Yellow Girl Point	S. 47° W.
Island south of Yellow Girl Point	S. 53° W.

Rat Lake, west end	S. 42° W.
" same rock surface as last	S. 60° W.
" east end	S. 44° W.
End Lake	S. 45° W.
Island in Yellow Girl Bay	S. 47° W.
Same rock surface as last	S. 56° W.
South shore, Yellow Girl Bay	S. 50° W.
" Yellow Girl Bay, 1 mile east of point	S. 48° W.
Mouth of Black River	S. 52° W.
A mile and a-half south of Black River	S. 50° W.
Rendezvous Point	S. 45° W.
South shore, Long Bay, 1½ mile east of Rendezvous Point	S. 48° W.
North shore, Long Bay, 2½ " " "	S. 45° W.
Mist Inlet, near mouth	S. 45° W.
" north end	S. 45° W.
North shore, Long Bay, 6 miles east of Rendezvous Point	S. 41° W.
South side, " 5½ " " "	S. 42° W.
" " 7 " " "	S. 45° W.
" " 8 " " "	S. 35° W.
Island in Long Bay, 8 " " "	S. 35° W.
North shore, " 7 " " "	S. 37° W.
" " 7½ " " "	S. 43° W.
" " 8 " " "	S. 42° W.
East end of Long Bay at Reed Narrows	S. 40° W.
Hudson Bay Co's. Post, White-fish Bay	S. 43° W.
Island in Sioux Narrows	S. 42° W.
South side, Sioux Narrows	S. 34° W.
Sioux Narrows	S. 40° W.
North Shore White-fish Bay, near passage	S. 42° W.
Shore two miles south of Yellow Girl Point	S. 65° W.
Island 1½ miles W. S. W. of Yellow Girl Point	S. 45° W.
North-west corner of Chisholm Island	S. 40° W.
Island north of east end of Cliff Island	S. 45° W.
Island north of Cliff Island	S. 50° W.
Shore of Grande Presqu'ile, 5½ miles east, of Mud Lake	S. 50° W.
" " " 4½ " " "	S. 45° W.
Island north-west end Cliff Island	S. 53° W.
Island south of Mouse Island	S. 45° W.
Gull Island	S. 50° W.
Island north of Gull Island	S. 45° W.
Island 1 mile north of Gull Island	S. 42° W.
Island 2 miles north of Gull Island	S. 42° W.
Island 2½ miles S. E. of Infernal Point	S. 50° W.
Island 1½ miles S. W. of Rope Island	S. 45° W.
South side of Infernal Point	S. 50° W.
Shore north of Crow Rock Channel	S. 37° W.
Island half a mile S. W. of Crow Rock Channel	S. 49° W.
North side Wiley Bay	S. 50° W.
South side Wiley Bay	S. 46° W.
Shore one mile S. W. of Wiley Point	S. 50° W.

Bottom of bay south of Wiley Point	S. 50° W.
Island one mile S. S. W. of Wiley Point	S. 54° W.
Island two miles east of Wiley Point	S. 48° W.
Island 1½ miles S. E. of Wiley Point	S. 45° W.
Island 1¾ mile S. E. of Wiley Point	S. 53° W.
North side Rope Island	S. 48° W.
East end Rope Island	S. 55° W.
North-east end of Kennedy Island	S. 55° W.
North shore of Kennedy Island	S. 50° W.
" " " same rock surface as last	S. 65° W.
Island north of Kennedy Island	S. 55° W.
Island east of Big Narrows Island	S. 52° W.
South-east side of Kennedy Island	S. 52° W.
West side of Kennedy Island	S. 55° W.
North side, east end of Big Narrows Island	S. 43° W.
North side Big Narrows Island	S. 51° W.
Island north of Big Narrows Island	S. 53° W.
Small Island north of Big Narrows Island	S. 54° W.
Shore, 2¾ miles S. W. of Wiley Point	S. 43. W.
North shore Big Narrows Island	S. 46° W.
" Big Narrows Island	S. 47° W.
North-west shore Big Narrows Island	S. 53° W.
" " " same rock surface as last	S. 85° W.
Island in the Big Narrows	S. 48° W.
" "	S. 49° W.
" " the same rock surface as last	S. 45° W.
North-west shore of Big Narrows Island	S. 46° W.
" " "	S. 55° W.
South shore of Big Narrows Island	S. 55° W.
South-west end of Big Narrows Island	S. 43° W.
Island at south end of the Big Narrows	S. 52° W.
Main shore of the Big Narrows	S. 35° W.
Shore 1¼ miles south of Picture Point	S. 45° W.
South-east end of Labyrinth Bay	S. 48° W.
South side Labyrinth Bay	S. 45° W.
Large Island in Labyrinth Bay	S. 50° W.
Island opposite mouth of Hell-diver Bay	S. 42° W.
Shoal Lake, north shore	S. 47° W.
" "	S. 45° W.
East side Indian Bay, Shoal Lake	S. 50° W.
North side Indian Bay, Shoal Lake	S. 52° W.
Island off south shore, Indian Bay	S. 45° W.
Shoal Lake, east side	S. 45° W.
Small island, south of Wood-chuck Island	S. 40° W.
Island 2¼ miles south of French Portage	S. 22″ W.
East side Tug channel	S. 40° W.
" "	S. 44° W.
East side of Falcon Island	S. 45° W.
" "	S. 40° W.
South-east side of Birch Island	S. 50° W.

South-west side of Cyclone Island	S. 35° W.
Small island west of Passage Island	S. 50° W.
Sabascosing Bay	S. 34° W.
Island south of Sabascosing Bay	S. 25° W.
Island ¾ mile S. E. of Starting Point	S. 40° W.
Island 1¼ mile S. S. E. of Starting Point	S. 38° W.
Island 3 miles N. W. of Sand Point	S. 50° W.
Shore 1¼ miles north of Sand Point	S. 35° W.
Shore ¾ mile N. E. of Sand Point	S. 43° W.
Large island west of Sand Point	S. 50° W.
Same shore as last, further west	S. 50° W.
South-west corner of Dog Island	S. 38° W.
North-east corner of Rubber Island	S. 48° W.
Mouth of Morton Bay	S. 42° W.
North end of Miles Bay	S. 32° W.
North-east shore of Miles Bay	S. 35° W.
Island off north shore of Big Island	S. 40° W.
North-east side of Big Island	S. 32° W.
South-east side of Big Island	S. 20° W.
" "	S. 37° W.
" " same rock surface as last	S. 75° W.
" " half mile from last	S. 35° W.
West side of Big Island	S. 32° W.
Massacre Island	S. 42° W.
Island 1¼ mile W. N. W. of north end of Bear Island	S. 40° W.
Island south of Oak Island	S. 38° W.
Louis Inlet (White-fish Bay)	S. 42° W.
Narrows Point "	S. 25° W.
Cat Point "	S. 18° W.
Steamboat Island, "	S. 40° W.
Squaw Island "	S. 40° W.
Bell Island "	S. 40° W.
Turtle Portage "	S. 30° W.

The following list of observations for the direction of the glacial striæ is given by Dr. G. M. Dawson, in his report on the "Geology and Resources of the Forty-ninth Parallel." The list is reproduced here, so that, taken with my own observations in the same and other portions of this region, the record may be as complete as possible. The bearings have been corrected for the magnetic variations to bring them into correspondence with the preceding.

North-west Angle Inlet.

McKay Island	S. 58° W. to S. 60° W.
Bucketé Island	S. 45° W.
North shore	S. 49° W.

South-westward from N. W. Angle Inlet.

Flag Island Point	S. 50° W.
" " "	S. 37° W.
" " "	S. 52° W.

Southern Promontory.

North-east Point	S. 33° W. S. 70° W. S. 35° W. S. 10° W. S. 65° W.
Cormorant rock	S. 33° W.

North of Rainy River (Mainland.)

	S. 22° W.
	S. 40° W.
Windy Point	S. 30° W.

Bigsby Island.

South end of	S. 37° W.
" "	S. 40° W.
" "	S. 30° W.
West side of	S. 80° W. & S. 20° W.
" "	S. 83° W. & S. 33° W.

Middle Island (?)

East side of	S. 15° W.
" "	S. 23° W.
North end of	S. 35° W.

North Island.

	S. 40° W.

North shore SandHill Lake, District of Shebashca.
(South side of the Grande Presqu'isle)

S. 35° W.
S. 50° W.
S. 45° W.
S. 44° W.
S. 35° W.
S. 30° W.
S. 35° W.

Northward from N. W. Angle to Rat Portage.

....	S. 40° W.
....	S. 46° W.
The Small Promontory..................	S. 45° W.
....	S. 43° W.
....	S. 33° W.
....	S. 42° W.
....	S. 50° W.
....	S. 40° W.
....	S. 43° W.
....	S. 49° W.
....	S. 52° W.
....	S. 63° W.
....	S. 55° W.
....	S. 58° W.
....	S. 50° W.
....	S. 48° W.
....	S. 45° W.
....	S. 45° W.
....	S. 52° W.
....	S. 42° W.
....	S. 37° W.
....	S. 40° W.
....	S. 50° W.
....	S. 48° W.
....	S. 30° W.
Lacrosse Island (Scotty Island.)............	S. 37° W.
" "	S. 50° W.
....	S. 45° W.
....	S. 45° W.
....	S. 32° W.
....	S. 27° W.
....	S. 25° W.
....	S. 30° W.
Rat Portage..............................	S. 35° W.
Rat Portage Fall..........................	S. 23° W.
" " (Winnipeg side)...................	S. 26° W.

General direction of the movement.

From these lists it will be observed that the great majority of the striæ have directions that lie between S. 35° W. and S. 55° W. About 18 per cent. of the observations shew the striæ to have a course outside of these limits. Of these, 13 per cent. have directions less than S. 35° W. and 5 per cent. greater than S. 55° W. The general average is about S. 45° W., or true north-east and south-west as the mean direction of the ice flow across the Lake of the Woods. The groovings, which are beyond the general limits of S. 35° W. to S. 55° W. may be regarded for the most part as abnormal local

digressions of the ice current, although in some instances, in the southern part of the lake, where one set of striæ is almost transverse to the usual set, the former seem to be due to a distinct and probably later ice current, as suggested by Dr. Dawson.

Later transverse striation

That post-glacial agencies other than those of the waters of the present lake have been engaged in the re-arrangement and stratification of the drift material there is abundant evidence. On the level of the railway track, a little to the east of Rossland, the gravel pit shews the following section of an old lacustrine deposit:—

Stratified deposit near Rossland.

1. Two feet (from surface) of fine, light yellow, sandy soil, with some vegetable loam and roots penetrating through it.
2. Eight inches finely bedded white and brown, extremely fine, almost impalpable sand, hardened and difficult to break with the fingers, with some inch and inch and a-half beds of coarser sand. Bedding, wavy.
3. Thin layer of white, calcareous matter, with roots and fragments of stems imbedded in it.
4. Same as No. 2, four to seven inches.
5. Same as No. 3.
6. Same as No. 2, four inches.
7. Same as No. 3.
8. Bedded, coarse reddish sand, eight inches.
9. Same as No. 8. but showing well-marked false bedding.
10. Coarse reddish sand, with large and small boulders, the whole shewing only feeble or no traces of stratification.

On Corn-field Island no hard rocks are exposed, but sections afforded by the shore shew a bedded gravel in which limestone pebbles are abundant, conformably resting upon compact, somewhat hardened bedded clays. Gravels and sands of the same character, in the same relative position, are exposed extensively on the Rainy River. The stratiform arrangement of this drift, due to post-glacial agencies, was not observed on islands or shores of the lake north of Corn-field Island and that noted at Rossland is on a much higher level. The stratified gravels and clays of the southern portion of the lake and Rainy River coincide approximately in their northern extension with the distribution of the limestone erratics, and with the northern line of the low sand-covered shores, and it appears not improbable that the line which defines the northward extension of all these, viz., the abundance of the finer kinds of drift, the limestone erratics and the stratiform arrangement of the clays and gravels, is the shore line at one of its most pronounced stages of a post-glacial sheet of water, the same with the hypothetical Lake Agassiz, which seems to have spread over so large a portion of this part of the continant, and left so many old beaches as

Drift deposits of southern lake.

the proof of its existence. If this supposition be well founded, then the Lake of the Woods, or at least its southern portion, is but a remnant of that much larger lake, and its drainage was consequently at one time by the south, till its southern end became dammed by deposits of sand.* Ice barriers may have constituted the northern shores of this immense lake, and in this case we would have an adequate explanation of the absence in considerable quantities of the finer drift, and of the absence of stratiform arrangement of the drift in the northern portion of the lake, since, by the time the ice had receded from this part, the waters may have subsided to too low a level to have covered the northern portion.

NOTES ON ECONOMIC RESOURCES.

Gold.

Mr. Coste's Report.

In the last Report of Progress, for 1882–4, Mr. E. Coste gives the result of his observations upon the occurrence of gold in the Lake of the Woods district, and upon the state of the gold mining industry at the time of his visit in 1883. Since his report was written, the condition of affairs has changed but little, and no real advancement has been made in any of the enterprises he describes, although the more sanguine and energetic prospectors continue to make discoveries, and bring in from the bush and the lake shores specimens of ore shewing free gold in quantities which are exceedingly encouraging, and which do much to sustain the belief of those who best know it that the Lake of the Woods is yet destined to become a permanent field for profitable mining enterprise. A few words will serve to supplement Mr. Coste's account of the state of the industry, and bring the history of the more important ventures to date. Since 1883, the Manitoba Consolidated mine has not been worked, and the adjoining Argyle mine has been equally unproductive. The proprietors of the latter, becoming apparently convinced of the inadvisability of further prosecuting the development of their location, have during the past season (1885) stripped the mill of its machinery and abandoned their works. Prior to this the mill had, in 1884, been employed in crushing a quantity of ore brought to it in barges from the Keewatin mine on Hay Island. These two mines were the only ones of any importance in the Clear-water Bay district, and their abandonment has destroyed the sanguine views that were lately entertained for the future of the district,

Clear-water Bay district.

* For additional facts bearing on this point see Geology and Resources of the Forty-ninth Parallel, pp. 217, 254.

and relegated it to a position of merely historic interest. A considerable number of exploratory pits to the depth of a few feet have been sunk on leads in various parts of this district, particularly in Echo Bay, the south side of Zig-zag Point, at Mr. Kendall's place at the east end of Clear-water Bay, and at Thompson's at the west end, but none of these seem to have as yet warranted more serious outlay than a few blasts and the assay of the ore thus secured.

Big-stone Bay district.

In the Big-stone Bay district, however, the state of affairs is more hopeful.

Pine Portage mine.

The Pine Portage mine, the most important and most promising venture in the district, was worked steadily throughout the summer of 1884, there being about a dozen hands employed. The shaft was sunk to a depth of 100 feet, and a drift run to a considerable distance to the south. The ore was milled as it was taken from the shaft. In 1885 very little work was done at the mine, but it is, I believe, the intention to continue operations during the coming season, the aspect of the vein and the character of the ore being fairly constant so far as developed, and warranting the vigorous prosecution of the enterprise. The reason assigned for the suspension of work is largely the difficulty encountered on the part of the proprietors in securing a thoroughly competent and experienced mining engineer to take charge of the operations of the mine, and their reluctance, in the light of experience, to enter upon any further serious outlay till such a manager can be procured. The position taken by the proprietors of the Pine Portage mine is a sound one, but one that brings into prominence the fact that in Canada or the adjoining States there are extremely few practically trained mining men, who, in addition to their knowledge of the economic management of the works and mine, possess also a scientific comprehension of the problems concerned in the extraction of the gold, which will enable them to study to advantage the milling of new ores such as these, and devise methods of treatment for particular cases which will preclude serious loss in the "tailings," such as has been the aggravating experience at the Pine Portage mine.

Keewatin mine

In 1884 a gang of men was employed for a considerable portion of the summer in mining, or rather quarrying, quartz from the lead of the Keewatin mine, at the point where it comes out upon the shore of Hay Island. The ore was shipped in barges to the stamp mill of the Argyle mine, where it was crushed. The lead seemed to carry considerable quantities of free gold, the crushed rock from drill holes almost invariably showing a very perceptible "colour" when washed. This work was done on the lead described by Mr. Coste as the "second vein" of the Keewatin mine. The exposure thus effected did not

serve to demonstrate a more definite character for the vein than that given by Mr. Coste, the quartz seemingly ramifying in various directions from a main mass or vein. In 1885 no work that I am aware of was done on this location. These two locations are the only ones that have been regularly worked for any considerable period since the time of Mr. Coste's visit. Preparations were being made in the autumn of 1885 for the resuming of work at the Winnipeg Consolidated mine.

Winnipeg Consolidated mine.

Prospecting.

While actual mining has thus advanced but little during the last two years, prospecting has been active and has resulted in promising finds. The best of these have been in the country to the east of Big-stone Bay and on an island in Yellow Girl Bay, where Mr. Moore found a lead, the upper decomposed earthy cap of which yielded me a fine shew of gold on washing. A number of specimens of quartz carrying visible gold have also been brought in from time to time by prospectors from the country to the east and south end of Big-stone Bay.

Position of Big-stone Bay deposits.

From what has been already observed by Mr. Coste regarding the disposition of the lines of veining in the neighborhood of Big-stone Bay, and from the geological features that I have sine been able to work out, a well-defined relation seems to be established between that disposition and the line of contact of the schistose hornblende-rocks, in which the veins occur, with the granitoid gneiss of the Laurentian.

Directions of veins.

Mr. Coste found the majority of the veins in this district to trend approximately either north-and-south or east-and-west and was disposed to classify them on this basis as probably due to two distinct systems of fissures, those of meridianal strike being of the most pronounced and well-defined characters. My own observations on the geological relations of these veins lead me to differ somewhat from this view, as regards at least some of the more important veins, which seem to me, although differing widely in their strike to be genetically associated, and to belong to a common system of veining. The Pine Portage lead is a fissure cutting a hard, massive schistose hornblende-rock (Section No. 12, p. 38 cc), at a distance of only 150 feet from a granite mass towards which it dips. The lead is parallel to the contact of schist and granite. The latter is part of the great granitic and gneissic Laurentian area to the east. This line of contact has been traced, as shown on the map, from its nearly north-and-south trend at the Pine Portage mine to the more nearly east-and-west strike which it assumes as it runs thence to the north of Big-stone Bay. The line is associated, to a greater or less extent, both to the west of Pine Portage, and to the east as far as the neighborhood of the Winnipeg Consolidated location on the south side, with quartz veins of a minor character, which are seen on the shores of the northern exten-

Conditions at Pine Portage mine.

sions of Big-stone Bay, and whose strikes are for the most part, though not always, coincident in direction with that of the line of contact. The larger veins of the Winnipig Consolidated, Lake of the Woods Mining Co., Bull-dog and other locations is a continuation of this intermittent line of quartz-filled fissures, which, although showing a north-and-south strike at Pine Portage mine and a nearly east-and-west strike at the east end of Big-stone Bay, belong to one and the same system, characterized by proximity to, and parallism with, the line of contact of the schists with the acidic and feldspathic rocks to the north and east. That line of contact is, as I have shewn in a previous portion of this report, eminently an igneous and brecciated one, the gneissic rocks having been in a soft and plastic condition in which were imbedded angular fragments of the schist and which penetrated the schist as injected dykes. Reasons for believing the veins a single system.

This association of a system of auriferous quartz leads with a line of igneous or granite contact is one of peculiar scientific interest. For the miner and prospector it is enough to know that there is such an association. To make it a guide in the search for auriferous veins in new fields would doubtless lead to promising discoveries. A guide to the prospecter.

The dip of the Pine Portage vein towards the granite mass at so short a distance to the east of it, is a feature of the mine that may develop interesting facts as the work proceeds. It is extremely difficult to discover whether the granite actually occupies an inferior position to the schist or the reverse. If the former is the case the shaft, if continued at its present incline in the vein, would strike the contact of the schist and granite at no great depth, and the analogy of some of the most successful mines would warrant the presumption of a concentration of metallic material in the neighborhood of the contact of two such diverse rocks, with the juxtaposition of which is so evidently associated the existence of the lead.

Silver, Copper, &c.

Silver occurs in the auriferous quartz veins of the Lake of the Woods, generally as an accessory mineral, in small quantities, but sometimes, as the assays of the ore of the Pine Portage mine show, in greater proportions by weight than the gold. No leads sufficiently rich in silver ore to be mined for that metal have as yet been discovered. Silver.

Copper pyrite is of very common occurrence in leads of quartz both of those that have been mined for gold and those that have not warranted such operations. It is not found, however, in sufficient quantities to be worked as an ore for copper, and the likelihood of copper mining becoming an industry here is a matter to be determined very largely as yet by the discoveries of the prospector. Copper.

Iron.

Deposits of iron ore have not been found as yet on the lake, although a large proportion of the rocks is very rich in disseminated magnetite. Magnetic sand, derived from the decomposition of the Laurention gneiss, occurs on the west side of Falcon Island, in stratified layers, which have evidently been so arranged by the sifting action of the waves on the beach, separating out the heavy magnetite from the light, silicious and feldspathic grains. The line of separation between the black magnetic sand and the light yellow sand is a very distinct one, and the percentage of magnetite in the former is large, but the deposit is an extremely recent one and the abundance of the magnetic sand is not such as to be of economic importance.

Other metallic minerals.

Zinc-blende and galena are not uncommon in such quartz veins as have been opened, and I have found both in small quantities in different parts of the district.

Molybdenite occurs in small veinules traversing the granitoid gneiss of Quarry Island, and I have been given large specimens of the same mineral said to have been found in the bush between Rossland and the Lake of the Woods.

Antimony ore is said to have been found in Ptarmigan Bay, but not so far as I could ascertain in any considerable quantity.

Cobalt is found to occur in traces. Mispickel and iron pyrite are comparatively abundant in veins of various dimensions, the larger of which may prove of value should the manufacture of arsenic and sulphuric acid ever become profitable in this part of the country.

Limestone.

Good limestone for the manufacture of lime for building purposes is an article of considerable local demand at Rat Portage and vicinity, and as the place increases in importance, either as a mining or a milling centre, or both, the necessity for a constant supply of this material at a moderate price will become more urgent. Up to the present no local source of supply has been utilized, so far as I am aware, and such quantities as have been absolutely needful have been brought as quick-lime from Winnipeg. The increase of price thus due to carriage has been a deterrent to its use in the building of the houses of the town, which are chiefly of wood, unplastered inside, and so less substantial, less comfortable, and more liable to destruction by fire than they otherwise would be. In view of the necessity for a supply of limestone for local purposes, I have been careful to note the occurrence of any limestones or dolomites that might be rendered available for the purpose.

There are two distinct sources from which limestone may be procured on the Lake of the Woods:—(1.) The numerous cream-colored, magnesian, limestone boulders that so thickly strew portions of the shore of the southern part of the lake. (2.) The vein-like deposits of crystalline dolomite found among the schists of the northern part of the lake. Sources of limestone.

Without reverting to the question of the probable source of the former, it may be stated that it burns to a lime of good properties, and is, in fact, precisely the same limestone that is burned at different points on the Red River. In Minnesota, to the south of the Lake of the Woods, this source of limestone is largely used, and it is found there that these drift boulders make the finest lime. Several thousand bushels are made annually in the western part of the state. Drift limestone is also used extensively in Iowa and Illinois for the manufacture of lime. There is no reason why that found on the islands and shore in the southern portion of the lake and on the Rainy River, where it is of common occurrence, might not be gathered and brought to a kiln at Rat Portage at less expense than the quarrying of the stone in place would entail, and thus not only supply the district with quick-lime at a moderate figure, but also add in a small though very practical way to the industries of the town. Drift limestone.

The limestones of the second class are found in limited quantities at different points on the shore and islands of the Lake of the Woods. They are generally of a dirty yellowish color on fresh fracture, and have the composition of a ferruginous dolomite, with more or less silicious matter, which detracts from the value of the lime. These dolomites are easily recognized by their deep brownish-yellow, ocherous weathering, due to the formation on the exposed surface of the hydrated oxide of the iron which is contained in the rock, probably as carbonate. When obtained moderately free from quartz it would make a fairly good lime after the necessary conditions of burning, such as duration of firing, etc, had been ascertained by trial on the large scale. One specimen of this ocherous-weathering, yellowish dolomite from Dispute Point was found on examination to contain only 6·5 per cent. insoluble matter, and is, therefore, for all economic purposes, a remarkably pure dolomite, though more or less ferruginous. Most of the exposures of this dolomite shew it, however, to be more quartzose, with the exception of one large vein-like deposit on the north side of Gaherty Island, about nine miles south of Rat Portage, where it was found to be very free from visible quartz. As there appears to be some doubt in the minds of those interested in the matter as to whether dolomite will make as good a lime as a pure non-magnesian limestone, it may be as well to quote the opinion on this subject of Prof. N. H. Dolomite veins.

Opinion of Prof. Winchell.

Winchell, State Geologist of Minnesota, who has made a special study of the relative merits of the various building materials of that State: "The lime that is made from magnesian limestones or dolomites differs from pure lime, both in composition and in its action when used. It was formerly supposed that the presence of a considerable per cent. of magnesia was detrimental to lime, and it used to be the aim of lime-burners to avoid such stones and seek for the pure limestones, or those that contained about 90 per cent. of carbonate of lime. But it has been found that the presence of magnesia, while probably actually reducing the quickly cementing quality of the lime, yet gives it that moderateness of slacking and setting which really makes it more useful in the hands of masons, and also prevents the waste and loss that arises from the immediate setting of pure limes. The magnesian limestones burn easier, the presence of the magnesia acting to disseminate the heat more perfectly through the whole than can be done with pure calcitic limestones, and also in some way apparently causing a granular, and often a vesicular, texture to pervade them, which allows the penetration of the heat within and the quick expulsion of the carbonic acid. As they burn more easily, so they slack more slowly, and with less heat evolved. They set more slowly also. This last quality is what makes them more useful than the pure limes. With a single spreading of mortar several bricks can be laid before the lime sets, but with pure lime but two or three bricks can be laid. This quality is especially desirable in plastering where some time is required in rubbing and smoothing the surface."

Supposed limestone.

A specimen from the north shore of Shoal Lake, which was apparently free from ferruginous and silicious matter, and of a gray color and finely granular texture, presenting the physical and chemical character of a limestone by the ordinary tests, was found to contain 68·6 per cent. of insoluble material, probably magnesian schists, which would cause it to approximate to soapstone in composition, although its hardness was much higher than that of the latter rock. Such a stone is, of course, totally unfit for purposes of lime-making.

Granite.

Different classes of granite.

A very large proportion of the more costly or ornamental building stones of the future cities of Manitoba and the North-west will undoubtedly come from the area of crystalline rocks which limits the prairie to the east and north-east. In this connection it is interesting to know that in the Lake of the Woods district there is an inexhaustible supply of good granite, in fine variety both as regards colour and texture. Both in the true granites and in the granitoid gneisses the

shades vary from very light gray to deep red, the latter color, however, being more characteristic of those granites to which a distinctly intrusive origin may be assigned than to the granitoid gneiss. On Quarry Island and elsewhere the gray granitoid gneisses have been quarried for blocks for bridge piers with very satisfactory results. The areas of intrusive granite are prominently coloured in carmine on the accompanying map. But although these granites are well distributed throughout the district and easy accessible by water, it is altogether probable that those exposures of granitoid gneiss found at intervals along the line of the Canadian Pacific railway will be first developed. The most promising of these exposures is one observed between Rat Portage and Rossland, where a highly colored, granitic rock of good quality affords exceptional facilities for quarrying and shipment, the line of the railway crossing the bare, level surface of the granite. In a city of the energy and ambition of Winnipeg there should be a moderate demand for granite, and with the growing towns to the west of it a very fair market might be established for this beautiful, ornamental and monumental stone.

Slate.

There is excellent roofing material in the slope of clay-slate on the Lake of the Woods, which will undoubltedly in time find a steady market in the enormous amount of building that will be the necessary concomitant of the development of the North-west. An enterprising effort has already been made towards the establishment of a slate-quarrying industry. In 1884 Mr. Gibbons opened a slate-quarry on an island lying to the west of Pipe-stone Point, and during the greater portion of the summer of that year had a gang of ten men engaged in taking out slate for the Winnipeg market. The work was not continued in 1885. The slate here quarried is not, however, the best that is to be found on the Lake. It is an evenly cleaving, soft, dark to glossy hydromicaceous schist, which presents unusually good facilities for quarrying due to the jointing which cuts across the planes of cleavage at definite intervals. The slate is readily cut or pierced by the slate-axe, taking an even edge, and not shattering when struck. It makes a fairly good roofing slate, but it is desirable, if the slate-quarrying industry is to be put upon a permanent footing, that the regular blue-black, slaty argilite, which is in general use by builders elsewhere, and which is found at several points in the lake, particularly in the neighborhood of Yellow Girl Point, should be worked first, as having the best chance of succeeding. Some of this slate from a small island north of Yellow Girl Point, was found on submitting it to rough tests to be remarkably non-absorbant, even in surface specimens.

Gibbons' quarry.

Prospectors in looking for slate quarrying locations on the lake are often at a loss to know when they really have a good slate or not. The following few simple rules, familiar to those in the trade, will enable them to distinguish a bad slate from a good one with sufficient certainty to be useful :—

Tests to be applied to slate.

(1) As a rule, good slate when struck gives a clear, bell-like sound.

(2) It is generally considered a good sign when it shatters more or less before the edge of the axe.

(3) Light-blue slate is less absorbent, as a rule, than black-blue varieties.

(4) Good slate has a hard, rough feel, while an absorbant slate feels smooth and greasy.

(5) The absorptive powers of a slate may be tested in two ways. (1) Place the slate on edge half immersed in water. If it draws up the water and becomes wet at the top in six or eight hours, it is spongy and bad. The extent to which the water ascends is roughly the measure of absorption. (2) Weigh a piece of the slate dry and then again after immersion in water for twelve hours, after wiping off the superficial moisture; if it shows much increase in weight it is too absorptive to be good.

The better qualities of slaty argillite do not occur extensively on the Lake of the Woods, but on part of the shore of Shore Island, and one to two and a half miles north-east of Yellow Girl, it occurs in sufficient abundance to be of considerable economic interest.

Talc, Soapstone, Potstone, &c.

Talc.

Pure talc, of pearly, whitish-green, foliated aspect, occurs in small, segregations in some of the softer green schists, of the islands of the lake, and some handsome specimens have been brought into Rat Portage, said to be from an island two miles south of the town. Although this pure talc is sometimes ground and used as a lubricant or polisher, it is doubtful if it occurs in sufficient quantities on the Lake of the Woods to be of economic value. The less pure, grey-coloured granular variety of talc, known as soapstone, or steatite, is, however, more abundant, and forms at least one extensive deposit which constitutes the rock on both sides of the canoe channel, one and three-quarter-miles south-west of French Portage for a distance of a hundred yards or more. This place has long been resorted to by the Indians for material for their pipes. Tho rock is soft, sectile, and frequently free from grit, taking a moderately fine polish with ease, it presents excellent facilities for quarrying, and would require no intermediate transport from the quarry to the barges. It lies within a few hundred yards of the regular

Soapstone.

tug channel through the lake, and will doubtless be of considerable value as the nearest source of supply of furnace linings, fire-stones, slabs, &c., when those commodities come into demand in Manitoba and the west. Its most important use lies in its refactory nature, when subjected to intense heat. It has other uses, however. In its powdered state it may be used as a "mineral paint," or in the absence of graptite as a lubricant for heavy machinery. Other uses, of a minor character, would help to make its working profitable if the industry were once established. On the west end of Ptarmigan Bay, dark-green chlorite, apparently the pure mineral, occurs in irregular veins in the hornblende-schist, and may prove of some value.

A valuable refactory material for the manufacture of fire bricks is found in the felsites and felsite-schists which are abundant in various parts of the Huronian area.

Serpentine Asbestus, &c.

As is indicated on the map, serpentine occurs in a number of places on the Lake of the Woods and Shoal Lake, but the varieties observed are not such as would make attractive ornamental stones. It is not associated with limestone and has not the clouded or mottled aspect usually found in marble formed by the association of these minerals in the same rock mass. The serpentines is of a dark, olive-green color for the most part, of a granular texture, and strongly impregnated with magnetite. Serpentine.

In the masses of serpentine occurring on the shore to the south-west of Wiley Point, numerous small veins of chrysotile or picrolite (commonly called asbestus) occur, and more careful prospecting might possibly reveal larger, workable quantities of this valuable variety of the mineral serpentine. True asbestus or fibrous hornblende is of general occurrence in the hornblende-schists of the Huronian area, particularly in small segregated bunches and along slickenslided surfaces. It was not observed to occur in quantities economically important. The most interesting localities are the rock sections between Winnipeg River and Rat Portage on the railway, Matheson's mica location at the south end of Falcon Island and on some of the Hades Islands. Asbestus in inconsiderable quantity.

Mica.

The pegmatite dykes which cut the schists and gneiss towards the southern portion of the lake give promise in places of affording a supply of mica in sheets sufficiently large to be of economic

Quarry at Falcon Island.

value. On the south side of Falcon Island two locations were taken up and first worked for mica in 1885. The rock exposure from which it is mined, or rather quarried, lies inland about a quarter of a mile north-west of the extreme south point of the island. At the time when I visited the location (June 30th, 1885) the pit was thirty-nine feet long, six to eight feet deep and about eight feet wide, cut across the whole width of a pegmatite dyke which seemed to strike in a north-west direction, although being covered for the most part, the strike is vague and uncertain. The dyke consists of orthoclase, chiefly in huge flesh-colored crystals, with some quartz and mica, which are intimately associated, and in the section appear to be segregated in irregular streaks, of a vein-like aspect, in a more or less vertical attitude. The mica, though in large crystals, bears a small ratio to the whole mass of the dyke. The mica taken out to that date was practically surface mineral, and it is not therefore a matter of surprise or disappointment that it should be rather clouded with films of iron oxide. A large proportion of it was quite good for the ordinary uses to which it is adapted and some of it had been proven to stand fire well by practical use in some of the coal stoves in Rat Portage during the previous winter. At depths farther removed from the weathering influences of the surface, clearer and less clouded crystals will very probably be found. Other mica "finds" have been reported from Sabaskong Bay and Big Island, as well as from Rainy Lake, but the location on Falcon Island is the only one that has been worked.

Hones and Whetstones.

Many of the felsites or micio-granites of the region are of sufficiently fine and compact texture to make good hones, and fragments of the more suitable varieties of mica-schist, which are in common use at Rat Portage and among the Indians, serve as excellent whet-stones.

Carbonaceous Schists.

Supposed graphite of no value.

Associated with the soft, fissile, hydromicaceous or magnesian schists of the lake there occur in several localities bands of jet black carbonaceous or sub-graphitic schists. These schists have a very characteristic vesicular structure and are strongly impregnated in most cases with pyrite. The present note is not for the purpose of calling attention to any economic value of these schists, but rather the reverse, viz., to point out their worthless character from an economic standpoint and so endeavour to save time and money to prospectors, who may be tempted to explore those bands in the belief that they have discovered

a graphite mine. As I have been consulted several times by prospectors at Rat Portage respecting the value of these carbonaceous schists, and as some seemed persuaded of their graphitic character, it may be useful to repeat that specimens from the band of carbonaceous schists that crops out on the shore, one mile south of the mouth of Ptarmigan Bay, examined in the laboratory of the Survey by Mr. Frank Adams, yielded only 5·773 per cent. of carbonaceous matter, after drying at 100° C; and another specimen lost 7·47 per cent. on ignition, nearly all, probably, carbonaceous. The opinion of Mr. W. F. Downs, chemist to the Joseph Dixon Crucible Co., Jersey City, is decisive as regards its commercial value. Half a dozen specimens from different localities were submitted to him, and speaking of the general character of the schist, he says:—"It is hardly plumbaginous, though certainly highly carbonaceous, and it lacks most of the distinguishing features of graphite. Its only possible economic value would be in the manufacture of cheap facings, but the ingredients of these are very cheap, so I see no value in it."

This does not preclude of course the possibility of discovering deposits of true graphite in the region.

Brick Clay.

Clay, suitable for the manufacture of bricks, is not plentiful in the northern portion of the lake or in the immediate vicinity of Rat Portage, a fact which is in harmony with the general paucity of the finer kinds of glacial drift in this portion of the region. The only locality where an attempt has been made in the direction of brick manufacture is at Fitzgerald's farm, about four miles south-west of Rat Portage, where, in the summer of 1884, some 50,000 bricks were made and placed upon the local market for chimney-building, &c. The brick thus turned out seemed to be somewhat arenaceous, but was strong and serviceable, and of a bright red colour. The demand has not apparently warranted the continuation of the manufacture, as I am not aware of any more brick having been burned up to date.

Apatite.

This valuable mineral, though common as a microscopic constituent of the massive rocks of the region, has not been found anywhere in deposits of economic value.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA
ALFRED R. C. SELWYN, LL.D., F.R.S., F.G.S., DIRECTOR.

REPORT

OF THE

MISTASSINI EXPEDITION.

1884-5.

BY

A. P. LOW, B.Ap.Sc.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.
1885.

ALFRED R. C. SELWYN, LL.D., F.R.S., etc.,

Director Geological and Natural History Survey of Canada.

SIR,—I herewith beg to submit my report of the Mistassini Expedition of 1884 and 1885.

I may take this opportunity of acknowledging the help kindly afforded me by all the officers of the Hudson Bay Company with whom I had the pleasure to come in contact.

I am,

Sir,

Your humble servant,

A. P. LOW.

REPORT

OF THE

MISTASSINI EXPEDITION,

1884–5.

BY

A. P. LOW, B.Ap.Sc.

According to instructions, I left Ottawa June 9th, 1884, to join the Mistassini Expedition, then being fitted out in Quebec, and reported there, June 12th, to Mr. John Bignell, in charge. I remained in Quebec, awaiting the departure of the party, until July 19th, when we proceeded to Rimouski, and were there again obliged to wait for the schooner engaged to transport the outfit from Quebec to Betsiamites, which did not arrive at Rimouski until the 25th, when we crossed to Betsiamites or Bersimis.

On account of further delay in engaging Indians and preparing the outfit, it was not until August 8th that I started, with one canoe and two men, up the Betsiamites River, in advance of the main party, for the purpose of making an examination of the rocks along the river as far as Lake Pipmuakin, where Mr. Bignell was to commence his survey. **Betsiamites or Bersimis River.**

We proceeded up the river and reached the first fall on the 11th, the distance being about forty-five miles in a north-west course. The river has been navigated to this point by a small steamer belonging to the lumber mill situated at its mouth.

The river valley, cut in the surrounding table-land, varies from a quarter of a mile to one mile in width. Its sides are formed by Laurentian hills, elevated from two to six hundred feet above the stream. These hills are well wooded with white and black spruce, tamarac, balsam-poplar and birch, and quantities of valuable timber are taken out every year, and cut up by the steam mill at the mouth of the river. The valley has been partly filled up by deposits of glacial drift, as the banks of the river are, for the most part, of sand **Timber.**

and clay, often upwards of fifty feet high. Much of the clay shows distinct evidence of stratification, and the different beds are seen highly crumpled and folded.

Between these banks, the river, varying from one to two hundred yards in breadth, flows with a swift and even current, and is joined by a number of small streams on either side, the chief one being the Neepee River, which flows from the eastward and joins the main stream at the head of tide, seven miles from the sea. This tributary descends into the valley by a beautiful fall, over 100 feet high.

Forest fires.

About thirty miles up the river and northwards, the country has been traversed by frequent and extensive fires, which have left very little of the original forest, the region being, for the most part, covered with second-growth timber of aspen-poplar, white birch, banksian pine, and spruce, none of which has attained a large size. The first fall is formed by two chutes, each being about fifty feet high, with a whirlpool between them, into which a large number of logs have, from time to time, been carried, and before escaping from its influence, having been so broken and bruised as to be unfit for commercial purposes, remain piled up on the shore. Above this fall the river runs N. 30° W., and continues in this direction for ten miles, with a sluggish current. The hills on either side rise to elevations from 800 to 1,000 feet above its level, being for the most part bare or covered with small second-growth timber.

The river now flows from the west for nine miles, in the lower four of which it is very rough, having four chutes of fifteen, ten, ten and twenty feet, respectively, with strong rapids between them, necessitating a portage of canoes for that distance.

From here to Waweashton, distant ten miles, the course is N. 35° W., with two short portages, passing falls of twelve and thirty feet.

Long Portage.

At Waweashton a large branch comes in from the eastward; and the main stream, turning westward, falls in the next ten miles fully 500 feet from the general plateau into the river valley, and is quite impassable for canoes, so that a portage, over a mountain upwards of 1,000 feet high, must be made. A week was spent transporting canoes, provisions, etc., over this distance. Beyond this, the river turns to the north, and for sixteen miles widens out into Lake Natuakimin, with a width of from one-half to one and a-half miles; lying very little below the general surface of the surrounding country, which is here comparatively flat, and characterized by low hills only, which seldom rise more than 200 feet above the water-level.

The river next runs from the west for fifteen miles, having become narrow and rapid, with a mile and a-half portage at the end of the course. The banks and country are similar to those on the last course.

Next turning to the north-east, the river, for a distance of eight miles, breaks in a straight line through the Labradorite hills, which form almost vertical walls on either side, rising from two to four hundred feet above the water, and producing the finest scenery met with on this route. Above this is Lake Pipmuakin, which was reached August 25th, and is distant by the river 135 miles from the sea.

Lake Pipmuakin.

This lake is very irregular in shape, being full of deep bays, and has an area of over 100 square miles. The Betsiamites River flows through it on the east side, the distance between inlet and outlet being nine miles. Several other smaller rivers and numerous brooks also empty into the lake.

The shores of the lake are principally low, but in places are rocky, and rise in elevations of one to two hundred feet above the water, the whole being covered with a fair growth of white spruce, balsam-spruce and white birch.

The waters of the lake and the Betsiamites River are well stocked with fish, the principal kinds being lake- and river-trout, white-fish, pike and sucker, and below the first fall of the river, salmon and sea-trout.

Arrival of Mr. Bignell.

Mr. Bignell having arrived at this lake on September 10th, the party was again divided, Mr. Bignell, with two canoes and four men, going by the Betsiamites River to Lake Manouan, by way of Lake Manouanis, while I, with five canoes and eight men, proceeded to the same point by a portage route to the Manouan River, and up that river to the lake.

Leaving Mr. Bignell, September 15th, we proceeded by a bay running to the north-west, to Pipmuakin River, a small stream discharging into the lake at the head of the bay, and distant twenty miles from the outlet. In crossing the lake, we were much delayed by wind, and did not reach the river until the 19th.

Pipmuakin River.

Having proceeded up the Pipmuakin River, through low, swampy country, a distance of twelve miles, the general course being N. 15° W., we left it, and, passing over four portages and three smaller lakes,) the total distance being five miles, direction north-west,) we reached a small lake called Otäshoao, which discharges, by a small river two miles long, into the Manouan River. This river is a branch of the Peribonka, which flows into Lake St. John, and takes its rise in Lake Manouan.

At the point where we entered it has a breadth of 200 yards. Proceeding up the river a distance of sixteen miles, course N. 20° W., a fall of fifty feet was reached. The stream below this flows with a slow current, varied by several short rapids, and passes through hills with from two to four hundred feet elevation, the whole having been burned over by frequent fires.

Manouan River

Beyond this fall the river narrows, becoming rapid, and continues so for eight miles, while the surrounding hills reach elevations from six to eight hundred feet above its level, and form a ridge extending from north-east to south-west. The river then flows with a slow uniform current for ten miles, course N. 10° E. through a country covered by low rounded hills, lying apparently in ridges, having a north-and-south direction. Beyond this the river spreads out, becoming very rapid and shallow for a distance of three miles. Here we left it, and proceeded by a portage route for nineteen miles, course north, through several small lakes and brooks to avoid a long bend in the river full of rapids and impractible for canoe travel.

The river was again reached about one mile below Lake Manouan, and continuing up it we entered that lake October 3rd.

Lake Manouan.

On arriving at Lake Manouan we passed around the north side, making a time survey of the lake, which was completed on the 8th.

This is another very irregular lake, being about twenty-two miles long from east to west, with several large deep bays on either side running north and south. Over most of its area it is studded with many islands, both great and small. The country around the lake is almost flat, being broken by ridges of hills only to the south and west. These rise not more than 300 feet above the lake, but have the appearance of high mountains from their contrast with the general flatness of the surrounding country. About one-half of the timber is destroyed by fire; what remains consists of white and black spruce, balsam-spruce and white birch, few trees exceeding eight inches in diameter at three feet from the ground.

Peribonka River.

We awaited the arrival of Mr. Bignell on Lake Manouan until the 14th, when, fearing that we would be frozen in before reaching the Peribonka River, we started by a portage-route from the west side of Lake Manouan, and passed through several small lakes connected by a small brook flowing into a branch of the Peribonka about twelve miles from Lake Manouan. On reaching this branch we descended it about sixteen miles, reaching the main river one-half mile below Lake Onistagan; general course, south-west. This lake is several miles long by two miles broad. Crossing it on the 16th, we continued up the Peribonka River, and reached a stream from the west, which enters the river about two miles below the main forks, being distant thirty miles from Lake Onistagan; course, a few degrees east of north.

The Peribonka, for the first twenty miles, varies from two to three hundred yards in width, and has little current, but for the remainder of the distance is narrow and full of heavy rapids. The country along the river is similar to that described around Lake Manouan. The forests here have also been devastated by fire. What remains of them shows a larger growth of trees than the last mentioned.

We ascended the tributary from the west six miles to a small lake, which, being found partly frozen over, we were compelled to discontinue our canoe voyage on October 23rd. A permanent camp was then formed, and Mr. Bignell joined us on November 4th, he having been stopped by ice on the Peribonka, about fifteen miles from Lake Onistagan. Winter camp.

After making toboggans for the transport of provisions and outfit, and as none of our party knew the route to Lake Mistassini, awaiting the arrival of a guide, we left the camp November 27th, and arrived at the Height of Land December 9th. The route travelled follows the branch, which flows through a chain of large lakes lying between ranges of low hills stretching from north to south. These hills have an average elevation of not more than fifty feet above the water-level. The land near the lakes, which cover the greater part of the surface of the country, is of a swampy character, clad with a thick growth of small black spruce and larch, and is wholly unfit for purposes of agriculture. The distance from the lake camp to the Height of Land is about forty miles, course nearly west. The lakes are well stocked with fish. Game is not abundant. Few ducks were seen on account of the absence of proper feeding-grounds, and no traces of moose or caribou were met with.

On crossing the Height of Land, we descended about 300 feet in twelve miles to Lake Temiscamie, a long lake running north and south, varying from one to three miles in width and very deep. An outpost from the Mistassini establishment was formerly located here by the Hudson Bay Company, but was abandoned some years back, as the Indians formerly trading here have either died or become accustomed to take their furs to Lake St. John for sale. Lake Temiscamie.

Following the Temiscamie River flowing out of the lake, which empties through Lake Mistassinis (Little Mistassini) into the great lake, for a distance of six miles, we passed through a very crooked lake about four miles long, and then continued down the river six miles, where we followed a portage route two miles long, and thus reached the north-east end of Lake Mistassinis on December 13th. The general course from Lake Temiscamie to this point is west-north-west. Lake Mistassinis.

The river continues almost parallel to the lake, and empties into it on the east side about thirty miles from its north end, running out again on the opposite side some distance farther north.

Lake Mistassinis, or Little Mistassini, is about fifty miles from north-east to south-west, lying parallel to the great lake, and is from one to eight miles wide, six miles being near the average breadth.

We passed down the east side to near the south-west end, where we crossed, and following a portage route through two small lakes about Lake Mistassini

four miles long in all, thus reached Lake Mistassini at a point about thirty miles to the north-east of the Hudson Bay post. By passing down the east shore we arrived at the post on December 23rd, thus finishing a long and difficult tramp on snowshoes, having walked for the last ten days of the journey on very short rations, with the thermometer ranging to forty degrees below zero.

Shortly after our arrival I made arrangements with Mr. Miller, the gentleman in charge of the post, by which I obtained quarters in his house, and there set up the instruments and took regular meteorological observations during the month of January. At the end of this time, having had several disagreements with Mr. Bignell regarding the operations of the party, I determined to return to Ottawa, and having arranged with Mr. Miller to continue the meteorological observations during my absence, I left on the 2nd of February, accompanied by two men whom Mr. Bignell was sending to Lake St. John with letters. On leaving the post we proceeded to the south-west end of the lake, crossing the Height of Land near that point, and, after traversing several small lakes, reached a branch of the Chief River, followed it to its junction with the Chamouchouan River, and continued down the latter, reaching Lake St. John February 21st.

Departure for Ottawa.

Two heavy snowstorms occurred while we were on the way, making the walking so difficult that our tent and sheet iron stove had to be abandoned, and we were obliged to sleep in the snow for more than a week.

The country passed through is very similar to that seen on the Peribonka River, and is described by Mr. W. McOuat in his report on the Mistassini River (Report of Progress Geol. Survey, 1871-72).

Since Mr. McOuat's exploration, the country has been wholly burned over, and few clumps of green woods remain.

Leaving Lake St. John February 23rd, I continued my journey with a horse and sleigh to Quebec, and reached Ottawa March 2nd. On the 23rd I received instructions to return to Mistassini, in charge of the party, and left Ottawa next day, accompanied by Mr. J. M. Macoun. Having been delayed in Montreal and Quebec, Lake St. John was not reached until April 5th.

Return to Mistassini.

Here we secured four men and provisions for the return trip through the kindness of Mr. J. H. Cummins, of the Hudson Bay Company, who also forwarded provisions for us to Lake Ashouapmouchouan, to be there stored until my men could return for them with canoes when the rivers had opened. Leaving Lake St. John, April 9th, with a party of eight, we started to return to Mistassini by the route taken by Mr. Jas. Richardson, a full report of which is given in the Geological Survey Report for 1870-71.

It was found necessary to travel mostly in the early morning, before the heat of the sun melted the crust on the snow. We therefore commenced our day's tramp about 3 a.m. and stopped about noon. We proceeded up the Chamouchouan River to the Shegobeesh Branch, and, following it to the lake at its head, crossed from it by a short portage to Lake Ashouapmouchouan, April 15th. Here, having replenished our stock of provisions, we continued up the Nikaubau River, through Lake Nikaubau and several smaller lakes, following the route laid down on Richardson's map, and reached the Height of Land. Mode of travelling.

Crossing this, we soon reached Lake Obatigoman, and, having passed along its eastern shore four miles, we passed overland to Lake Chibougamoo, arriving there on the 20th of April. Up to this time the weather, being cold and clear, was very favorable for travelling, but we were now overtaken by a period of mild weather, which made the snow so soft and heavy as to render tramping with loads almost impossible. In addition to this we were short of provisions, and on the 24th I decided to send four men ahead without loads, with instructions to reach the Hudson Bay post on Mistassini and send back provisions from there. These men travelled over sixty miles in forty hours, without food, and thus reached the post. From here two Indians were sent back with provisions to relieve us, and arrived at our camp, on the east side of Lake Chebougamoo, April 28th. Continuing our journey from this point, we reached the post next day. Delay.

On arriving at Mistassini I found Mr. Bignell encamped there, with about half his party, the remainder being engaged bringing in the canoes left on the Peribonka at the close of navigation. During my absence Mr. Bignell had returned to Lake Onistagan, and continued his survey from that point to the entrance of the Temiscamie River into Lake Mistassinis. Arrival at Mistassini.

Mr. Bignell's party and my men were unable to move until May 28th, owing to the breaking up of the ice and the opening of navigation. Mr. Bignell, with his party, then descended to Lake St. John, while I sent six men, with three canoes, to Lake Ashouapmouchouan, to bring in the provisions drawn and stored there during the winter. After a very rough and dangerous trip, owing to the spring freshets in the rivers, the men returned on the 27th of June.

Mr. Macoun and myself were employed during their absence in keeping meteorological observations, determining the latitude of the post, and in collecting specimens of, and making notes on, the natural history of the vicinity. Having engaged two Indians as guides, we left the post June 30th, and, passing up the lake, reached the end of Mr. McOuat's survey on the west side, three miles beyond the discharge of the lake, on July 3rd.

Having determined the latitude of this point, we continued the survey to the north end, and thence back down the east side, connecting again with McOuat's survey at the "Big Narrows." The distances were measured with a Rochon micrometer, the angles with a transit theodolite, and frequent observations for latitude were made with the sextant as a check on the scaling.

Having completed the survey of the lake, we returned to the Hudson Bay post July 22nd. Being short of provisions, in consequence of one-half of our supply of pork having been stolen by Indians from the camp at Lake Ashouapmouchouan, I now determined to send my men back to Lake St. John.

Mr. Macoun and myself remained at the post until the arrival of the Hudson Bay Company's canoes from Rupert House, and had made arrangements to descend the Rupert River with them on their return trip to James Bay. This delayed us till the 22nd of August.

Lake Mistassini.

Père Charles Albanel.

The first person who has left any written account of his explorations of Lake Mistassini was Père Charles Albanel, a Jesuit missionary, who crossed it, in 1672, on his way from Lake St. John to Hudson Bay, which he reached by descending the Rupert River.

The following account of his exploration is taken from the "Relations des Jesuits dans la Nouvelle France," vol. iii, pp. 49-50, entitled "Voyage de la Mer du Nord par terre, et la découverte de la Baie de Hudson. Mission de Saint François-Xavier, en 1671 et 1672. Père Chas. Albanel:"—

"Le 18 (June) nous entrasmes dans le grand Lac des Mistassirmins, qu'on tient estre si grande qu'il faut vingt jours de beau temps pour en faire le tour. Ce Lac tire son nom des rochers dont il est remply, qui sont d'une prodigieuse grosseur; il y a quantité de très belles iles du gibier, et du poissons de toute espece, les orignaux, les ours, les caribous, le porc-epic, et les castors y sont en abondance. Nous avions déja fait six lieuës au travers des iles qui l'entrecoupent, quand j'aperçeu comme une éminence de terre d'aussi loin que la veuë se peut estendre; je demanday à nos gens si c'estoit vers cet endroit qu'ils nous falloit aller? 'Tais-toy,' me dit nostre guide, 'ne le regarde point, si tu ne veux perir.'

"Les sauvages de toutes ces contrées s'imaginent que quiconque veut traverser ce lac se doit soigneusement garder de la curiosité de regarder cette route, et principalement le lieu où l'on doit aborder, son seul aspect, disent-ils cause l'agitation des eaux, et forme des tempestes qui font transir de frayeur les plus assurer."

The above is all that Père Albanel has written concerning the lake, and as he must have crossed only the southern end on his way to the Rupert River portage, he could speak only by hearsay of the remainder of the lake. He probably obtained his idea of the lake, and the number of days required to make the tour, from the Indians living around it, and if they were not more truthful than their present descendants now are, their testimony was not to be relied on. Six leagues is about the distance he would have had to travel down the south-east bay before reaching the islands off the point, at the present crossing place, and here the islands are about six miles distant from either shore. He could not have remained long at Mistassini, as he arrived at Lake Nemiskou, on the Rupert River, on June 25th, and six days are required to canoe that distance.

The next explorer to reach Mistassini was the French botanist Michaux, who, in 1792, ascended the Mistassini River from Lake St. John, and traversed the lake to the Rupert River, intending to descend it to James Bay, but, owing to the season being far advanced, he abandoned this project and returned to Lake St. John. Michaux followed the route taken by Père Albanel, and quotes him for his description. Michaux.

The Hudson Bay Company have had a trading post on the shores of the lake for over one hundred years. This post was first situated near the outlet, but owing to the difficulty in procuring an adequate supply of fish, the staple article of food, the post was removed, over fifty years ago, to its present position on the south-east bay. During the time of the North-West Trading Company, they also had a trading post at the southern end of the south-east bay.

In 1870, Mr. Jas. Richardson, of the Geological Survey, was sent to explore the country to the north of Lake St. John. He ascended the Chamouchouan River, and reached the southern end of Mistassini, but, owing to the failure of his supply of provisions, he was obliged to return without seeing the main body of the lake. Geological Survey.

The next year, Mr. Walter McOuat was sent out to continue the survey. He proceeded from Lake St. John by the Mistassini River, making a survey of the route followed, and succeeded in surveying about one-half of the shore line of the lake, when he also was obliged to return for want of provisions.

Nothing farther was done towards finishing the survey until, owing to the request of the Quebec Geographical Society in 1883, the present expedition was dispatched by the Geological Survey and the Quebec Government. As the season was far advanced before the party was formed, it was deemed advisable to delay its departure until the season of 1884.

Derivation. The name Mistassini is formed from two Algonkin words—"mista," signifying big, and "assine," a stone; and is so called because of the large boulders of gneiss strewn along the west shore.

Size. Lake Mistassini is a long and narrow body of water, stretching from north-east to south-west, with a perceptible curve between the ends, the concavity of the curve being towards the south-east. It lies between N. Lat. 50° and 51° 24′, W. Long. 72° 45′ to 74° 20′. The length, in a straight line between the extremities of the north-east and south-west bays, is nearly one hundred miles, the average breadth of the main body being about twelve miles. At either end of the lake, a long point stretches out, dividing the ends into two deep bays. Between the points, and seemingly a continuation of them, is a long chain of rocky islands, which, by overlapping each other, almost divide the lake into two parts, so that a view of the opposite side is rarely obtained in going around the shore. A slight decrease in the present level of the lake would result in the production of two separate lakes, as the water between the islands is quite shallow, and forms a contrast in this respect with the great depth between the islands and shore on either side. Here the lake is very deep, an isolated sounding, made in crossing, having given 374 feet at a point which, I was informed, was not the deepest part of the lake.

The bay at the south-east end of the lake is called Abatagush. This bay, sixteen miles from its mouth, is again divided by a long point into two other bays. About four miles from the end of this point, and on it, the Hudson Bay post is situated.

Cabistachuan Bay. The eastern part, called Cabistachuan Bay, runs slightly east of south, in an irregular course, for about twelve miles, the Little Perch River coming in at its head. The western part is much larger and more irregular. It stretches south for sixteen miles, a small river from Lake Wakiniche falling into it at that distance. A side branch of the bay runs to the westward for upwards of ten miles. The general width of Abatagush Bay is one and one-half miles. The south-west, or Poonichaun Bay, for a distance of twenty miles from its entrance, has an average breadth of about five miles. Its shores are broken by smaller bays, and its surface is covered with islands, varying from six miles long, by one and one-half wide, to mere boulders. After the first twenty miles, the bay narrows to an average breadth of less than one-half mile, and continues in a south-westerly course for a long distance, as the end was not reached after ascending it fourteen miles. The Indians say that a large river empties into the lake at the head of this bay. The north-east and north-west bays are not so deep as the southern ones; the distance from the end of the point to the mouth of the

Northern rivers. Papasqutsatee River, a large stream coming in at the head of the

north-west bay, being fifteen miles, with an average breadth of rather more than four miles. From the mouth of the Toquaoeo River, which enters the north-east bay at its head, to the end of the point, the distance is nineteen miles, the average breadth being under four miles. By this river a canoe route goes to a Hudson Bay post, called Nitchicoon, situated on a branch of the East Main River, to the north-east. This stream falls rapidly during the dry season, being an exception to the other rivers running into the lake, which, taking their rise in large lakes, are not greatly affected by local rainfall.

Beside those above referred to, the large river flowing out of Lake Temiscamie, and passing through Lake Mistassini, enters the lake on the east side about twenty miles from the head of the north-east bay. Almost directly opposite this river, on the west side, a smaller stream, called the Wabassinon River, enters.

The shore of the lake is indented by a number of smaller bays, and many islands also occur along its margin.

The shores of the lake are mostly rocky, with no marshes or beach, a fact accounting for the absence of any great numbers of wading birds or graminaceous ducks. The western bank rises from thirty to sixty feet above the surface of the water, and is in many places perpendicular. The eastern bank is not so elevated, and rises more gradually.

To the south of Mistassini, and running north of east, is a ridge of hills forming an escarpment about 300 feet high, and constituting the Height of Land between the waters flowing to the St. Lawrence and those draining to Hudson Bay, and the division line between the Province of Quebec and the North-east Territory. To the north is another range, passing within ten miles of the lake and trending away to the westward. The highest of these hills does not rise more than 500 feet above the level of the lake. Hills.

The country in the vicinity of the lake is generally slightly rolling, with rounded hills, rising from thirty to sixty feet above the water, and interspersed with numerous small lakes and marshes.

As will be seen from the following summary, compiled from the daily meterological observations taken at the Hudson Bay post on Mistassini, which are given in detail in Appendix (II), the climate unfits the surrounding country for purposes of agriculture, as frosts occur during every month except July.

I am told that the season of 1885 was a good average of the climate here, except that the rainfall was excessive.

SUMMARY OF METEOROLOGICAL OBSERVATIONS, LAKE MISTASSINI, 1885.

	Jan.	Feb.	March.	April.	May.	June.	July.	August.
Mean temperature	—18.5	—00.1	01.9	25.3	42.3	53.1	59.9	56.7
Highest temperature	16	39	35	54	85	79	76	81
Lowest temperature	—56	—46	—47	—19	08	30	39	31
Monthly range	72	85	82	73	77	49	37	50
Mean maximum temperature	—05.1	11.1	16.6	30.6	53.6	64.7	67.0	68.1
Mean minimum temperature	—31.6	—09.2	—18.0	16.0	29.3	39.4	49.8	45.7
Mean daily range	26.5	20.3	34.6	14.6	24.3	25.3	17.2	22.4
Number of days' rain	....	....	....	4	17	20	....	21
Number of days' snow	13	10	13	8	2	2	....	....
Number of fair days	12	16	19	16	12	12	....	9
Resultant direction of wind	N.45°E.	N.56°E.	N.74°E.	N.20°E.	N.48°W	S. 80°W	S. 40°W	S. 67°W

Snow covers the ground about the middle of October, and remains until late in May, all the smaller lakes being frozen over during that time.

The main body of Lake Mistassini is an exception, as owing to its depth and consequent slow change of temperature, it does not generally freeze over before December 20th, and opens a couple of weeks later than the other lakes in spring.

During the summer months the sky is clouded a greater part of the time, accompanied by drizzing rains and heavy thunder storms. The soil of the country overlying the limestone basin, on and about Lake Mistassini, is a sandy loam with clay subsoil, and would yield good crops in a more favorable climate.

Short summer.

On the main body of the lake, and to the northward, the summer season is shorter and colder than in the vicinity of the post. During the month of July, the low lands bordering the lake were frozen solid within one foot of the surface, in all places where the trees were at all dense. This marked difference is undoubtedly due to the proximity to such a large body of cold water, which lowers the general temperature of the air during the warmer portions of the year. The soil overlying the Laurentian gneisses and schists is light and sandy, only a thin layer generally resting on these rocks.

Agriculture.

At the Hudson Bay post, the most favorable point on the lake for agriculture, a poor crop of potatoes is raised yearly. They are small, as the tops are always frozen before reaching maturity. In the spring, as soon as the frost was out of the ground, I sowed garden peas, beans, corn, and turnips. On August 20th the peas were beginning to fill the pods, the beans were in flower, and the corn only eighteen inches above the ground; the turnips alone were growing nicely. I believe that barley has been sown here, but would not ripen. A full list of trees and plants, with their distribution, is given in Appendix (I) by Mr. Macoun, and I will only add that no timber of commercial value was seen near the lake.

Covering the higher ground, at the southern end, white spruce, poplar, balsam-spruce and white birch trees were found, some of which had a diameter of eighteen inches, three feet from the ground. The swamps are covered with a thick growth of small-sized black spruce and tamarac, and the small areas of burned land are generally clad with a second-growth of banksian pine. Trees.

Mr. Macoun, in his report, also gives a list of the birds found about the lake. The waters of Mistassini and all the adjoining large lakes are full of fish. The principal kinds are lake-trout, river-trout, white-fish, pike, pickerel, and sucker, all of large size and fine quality. These fisheries would be of considerable commercial value if access could be had to them by railway. Fish.

Fish is the chief article of food of the Indians around the lake. During the spawning season in the autumn, when the fish come into the shallow water, large numbers are caught in nets, then cleaned and smoked for the winter supply. In the winter, the fish are caught on hooks through holes in the ice. The Hudson Bay Company's people also catch and salt a large quantity.

There are twenty-six families of Indians, about one hundred and twenty-five persons in all, living around the lake and trading with the Hudson Bay Company there. These Indians speak a dialect of the Algonkin language, and belong to the Mistassini tribe of that great family. They are mostly short, and of poor physique, although there are exceptions to the rule. Very few of them are now of pure Indian blood. They live by hunting fur-bearing animals during the winter, the skins of which they barter with the Hudson Bay Company for flour and other provisions, and articles of clothing. Indians.

As there are no longer any deer in the country, and small game, such as rabbits and partridges, are scarce; if it were not for the provisions supplied by the Company, these Indians would be unable to live. As it is, cases of death by starvation are by no means uncommon during the winter. In the summer, all the able-bodied men descend the Rupert River in large canoes to Rupert House, with the furs taken during the winter, and return with supplies for the ensuing year.

The greater part of these Indians can read and write in the Cree characters, and have several books printed in that form. They all profess Christianity, although it is mingled with their old beliefs, as they still have their sorcerers, who profess to be able to do many things by the aid of evil spirits. A missionary, under the Church Missionary Society of England, comes inland from Hudson Bay once in two or three years, and performs the ceremonies of marriage and christening as required. During his absence, one of the Indians conducts the church service at all gatherings.

General Description of the Rupert River.

As the journey from Lake Mistassini to Rupert House was hurried, and consequently large areas of country were passed over in a short space of time, I will, in the following, give extracts from my daily journal *en route*:—

August 22nd.—Mr. Macoun and myself left the Hudson Bay post at Mistassini at 4 p.m., in a large canoe, with ten men paddling, and camped for the night at the "Big Narrows," eighteen miles from the post.

August 23rd.—Started at daybreak, and crossed the lake to the west side; proceeded up the shore to the Portage Bay, distant ten miles from the outlet of the river. Here, passing over a low, rocky ridge, by a portage two hundred yards long, we entered the Rupert River, and descended it a distance of ten miles, in a course of N. 16° W., to a short portage, crossing a long point, made to avoid heavy rapids in the river. Camped on the portage.

Rupert River.

The outlet of Lake Mistassini is about one hundred yards wide. Immediately below this the river spreads out, and forms numerous channels between the islands with which it is covered. The river is so covered, and has a breadth varying from one-quarter to two miles, as far as the last portage. The surrounding country is almost flat, with low, rounded hills, never exceeding fifty feet elevation above the level of the river. The timber is principally black spruce and white birch, with poplar, tamarac and banksian pine; all of small size, never having a diameter exceeding six inches, three feet from the ground. Timber burnt near the portages.

August 24th.—Continued down the river, now narrowing to a breadth varying from one hundred yards to one mile, having a swift current, with several small rapids which are passed by portages in ascending the river. The river continues full of small rocky islands. Distance travelled to-day thirty miles in a general northerly course. The country passed is not so flat as yesterday, some hills rising from seventy-five to one hundred feet above the river. The prevailing timber is black spruce, birch, banksian pine and tamarac, all of small size.

The greater part of the south-west side has been burnt, and is covered with a second-growth of white birch. The north-east shore is unburnt, and black spruce predominates.

Heavy gale from the west, with showers of rain, all day, making it very cold and disagreeable to travel.

25th.—Continued down the river eleven miles to Lake Miskittenow, through the east end of which the river flows.

This lake is seven miles long, course west, with an average breadth of one and one-half miles. On the north side of the west end is a hill of about three hundred feet elevation, forming a conspicuous landmark and called Miskittenow Mountain. Leave the Rupert.

Leaving the river, we passed to the upper end of the lake, and thence, by a portage of 1,100 yards, to Lake Kanataikow. Passing through this lake, which is very crooked, for nine miles, we crossed a portage, one-quarter mile long, to a small lake called Kakomenhane, and then through it three miles to the portage at the opposite end, where camp was made for the night. General course of travel for the day, N. 55° W. The country passed through was rougher than yesterday, with rounded hills rising from one to three hundred feet above the general level.

The timber consists of small spruce, birch, banksian pine and tamarac, mostly of second-growth.

26th.—Left camp at daybreak, and, crossing the portage, 250 yards long, entered Wabistan Lake, the head of the Marten branch of the Rupert River. We followed this lake eight miles to its outlet by a small brook 300 yards long, then across a small lake one and a-quarter miles, and down the river two and a-quarter miles, to another small lake, and on through Lake Mok-how-as-took for thirteen miles. Thence through seven small lakes connected by the river. Total distance, forty-seven miles; direction, N. 60° W. Timber very small and mostly of second-growth banksian pine, with black spruce and birch. Marten branch.

27th.—Continued down the Marten River, passing three small lakes in thirteen miles to Jacob's Lake, and through it eleven miles. Its shores are burnt and covered with large boulders. From here down the river ten miles to Robert's Lake, camping at its outlet, five miles from the inlet. Total distance, forty miles; course, N. W. The country was flatter than yesterday, no hills exceeding one hundred and fifty feet in elevation. Much more burnt land was seen than on previous days. The timber was very small, no trees exceeding six inches in diameter, three feet from the ground, and consisted principally of black spruce. A few small balsam-spruce were seen on the low river bank during the afternoon.

28th.—Heavy frost last night. Travelled all day on the Marten River, passing through four lakes, called, respectively, Ka-we-wat-in-ou, Te-say-kow, Cooper's and Gull; also made portages past several small rapids in the river. Total distance, thirty-six miles; direction, N. W. Country flatter than yesterday, and densely wooded with black spruce and tamarac, with little birch. Not much burnt land. Soil poor and swampy or bare rock. Lakes.

29th.—Continued down the Marten River, passing five small chutes by portages, the aggregate fall in seventeen miles being one hundred and ten feet.

Re-enter Rupert River. Here the Marten enters the Rupert River. Passing down the Rupert, which here has an average breadth of one-half mile, the Nitchicoon branch was passed, two and a-half miles below.

By this river the canoes bound for the Hudson Bay post at Nitchicoon, on the East Main River, leave the Rupert, and reach that river through a system of lakes similar to that passed on the Marten.

Continuing down the Rupert, with a swift current, for six miles, a fall and rapid of twenty feet is passed by a portage one-half mile long; thence the river runs with a swift current three miles, to the entrance of Lake Nemiskow. Passing down the lake eight miles, we camped on a small island, where the Hudson Bay Company have stored a supply of provisions for the Indians wintering in the vicinity. The country passed through to-day was much lower than yesterday, being nearly flat; the timber much the same, with more second-growth birch and poplar of small size. Lake Nemiskow is silted up by the detritus brought down by the river for a distance of two miles beyond where we camped, and is characterized by low islands and sand-banks, clad with willow-bush and reeds, through which a channel, half a mile wide, runs.

Lake Nemiscow

30th.—Proceeded down the lake to an encampment of Indians from Rupert House, who were engaged netting and smoking small sturgeon for winter use. Left again at 2.30 p.m., and followed the north-east bay six and a-half miles to the smaller discharge.

Lake Nemiskow is made up of three deep bays, forming a Y; each being about fifteen miles long, with an average breadth of three miles. The Rupert River flows in by the south-east bay, and out again about half-way up the north-east, having two outlets, the larger being several miles farther north than the smaller. A large river flows into the south-west bay, and forms the canoe route to Washwanaby, a Hudson Bay post on the Notaway River. Several other large streams flow into the lake.

The surrounding country is comparatively flat, being highest to the south-west, where the hills probably have an elevation above the water of 200 feet. To the north and east is much lower and swampy. The waters of the lake are shallow.

Père Albanel says, in the Relations des Jesuits, that ten days are required to make a circuit of the lake, and that it is surrounded by high mountains, forming a semicircle from south to north.

Leaving by the smaller discharge, we descended it two miles to a portage 600 yards long, past a rapid and fall of forty feet. Camped at

the end of portage. The timber was slightly better than yesterday, with bluffs of poplar and birch along the lake, and no burnt land.

31st.—Continuing down stream, the main discharge was reached by a portage one-quarter mile long, past a rapid with ten feet of fall, distant four and one-half miles from camp; the general course from Lake Nemiskow to this point being N. 20° W. The river now runs with a swift current, and small rapids, twenty-six miles in a course N. 50° W. to the Oatmeal Fall. This, like the other falls on the river, consists of a chute, with heavy rapids at the bottom. Oatmeal Fall.

The Oatmeal Fall is passed by a portage one and a-quarter miles long. Below it, at a distance of two and three-quarter miles, another fall, thirty-five feet high, called the White Beaver, entails a further portage of half-a-mile. Beyond this, the river flows rapidly for seven and a-half miles to where we camped for the night.

The country passed was very flat, until the Oatmeal Fall was reached, below which the river flows in a valley, between banks from thirty to fifty feet high. Above this no distinct valley was observed. The timber becomes larger and better as we descend, and no burnt woods were seen, except on the portages and between the Oatmeal and White Beaver Falls.

September 1st.—Proceeding down the river, between banks from twenty to fifty feet high, for six miles, the first portage of "The Fours" was reached. This portage, three-quarters of a mile long, passes a heavy rapid and fall of fifty feet. One-half mile below is the second portage, over a chute of seventy-five feet; then, three-quarters of a mile to the third chute of fifty feet, passed by a portage of half-a-mile and down heavy rapids to the last portage, over rapids with a fall of thirty feet in quarter of a mile.

The country was higher to-day and the soil better. The timber was much larger. Balsam-poplar was first seen since leaving Mistassini, also balsam-spruce, with the exception of a few trees on the Marten river mentioned above. White spruce, having a diameter of twenty inches, three feet from the ground, was observed on the portages at "The Fours." Very little of the timber is burnt. The country seems to be descending in a series of low terraces, similar to those seen on the shores of the St. Lawrence River; each fall on the Rupert being caused by the passage of the river over an escarpment. Timber.

September 2nd.—For seven miles the river flows with a moderate current, with one small rapid, three-quarters of a mile long, to the Shekash portage, one and a-quarter miles long, passing a rapid and chute of seventy-five feet. Beyond this, the moderate current continues for ten miles, when another chute of twenty feet is passed by the Cat portage, one-quarter mile long. The river then again flows

steadily for eleven miles, to another rapid of twenty feet, where we camped. As far as the Cat portage, the river flows between clay banks from twenty to forty feet high, densely wooded with large poplar and white spruce; below this, the country became very flat and swampy, covered with small black spruce, tamarac and second-growth poplar. General course travelled during the day, N. 70° W.

3rd.—Started early to-day, running the Plum-pudding rapid, one and a-half miles long, with fifteen feet fall, and thence two miles to Smoke Hill rapid, having a fall of twenty-five feet, and passed by a portage of one mile. Below, the river runs with a moderate current for ten miles, when the last rapid, one mile long, with ten feet fall, full of large boulders, was run, and Rupert House, one mile below, was reached.

Rupert House.

Rupert House is situated at the mouth of the river, which empties into Rupert Bay, an extension of James Bay.

At this point the river has a width of upwards of one mile, and discharges a volume of water estimated equal to that of the Ottawa River at Ottawa.

The country between Plum-Pudding Rapid and the mouth of the river is very flat and swampy, covered with only a fair growth of timber. The soil is chiefly a heavy clay, and is generally too wet and cold for agricultural purposes.

Return to Ottawa.

At Rupert House, garden vegetables are cultivated with fair success; barley is also grown, but seldom ripens, owing to the shortness of the season and frosts during the summer. At Rupert House our season's work was completed, aud we hastened to return to Ottawa. We were not able to leave, however, until the 9th, when we crossed the foot of James Bay to Moose Factory, a distance of one hundred and twenty miles, in a large canoe, with six men. The water of the bay is very shallow; so much so, that when the tide is out, nothing but mud flats can be seen.

Having been delayed by high winds, Moose Factory was not reached until the 14th. Having here changed our canoe for a smaller one, with three men, we started up the Moose River next day, and reached Dog Lake, at the Height of Land, on the 29th. Here taking the Canadian Pacific Railway, we arrived in Ottawa October 2nd.

Geological Notes.

With the exception of the comparatively small areas of Huronian and Cambrian rocks, found in the vicinity of Lake Mistassini, the Laurentian gneisses and associated rocks occupy the whole country from the Gulf of St. Lawrence to James Bay, along the route traversed by this expedition. Of these rocks, the red gneiss, composed of red

orthoclase, grey quartz and black mica, predominates; with hornblende gneisses and schists, mica schists, crystalline limestones, and an area of triclinic feldspar rocks.

In the following pages a detailed statement of the rocks met with in ascending the Betsiamites River and on the route to Lake Mistassini and James Bay is given.

The rocks are first seen on the Betsiamites, seven miles from its mouth, and opposite the mouth of the Nepee River, where the hills of the Laurentian range are entered. Between this point and the coast, the river flows between sand-banks, with an elevation varying from twenty to fifty feet.

The first hundred feet of the exposure is dark-red, coarse-grained gneiss, composed of red orthoclase, grey quartz and mica. Dip S. 50° W. at a high angle. Then, for 600 feet, light red, fine-grained gneiss, in which the quartz greatly predominates, banded with coarse dark-red gneiss, composed chiefly of red orthoclase and grey quartz, with a small quantity of dark-green decomposed hornblende and mica. Also light-greyish gneiss, containing large proportions of black mica and dark-green hornblende. One hundred yards beyond the last, dark-red, coarse-grained gneiss, alternating with fine-grained bands for fifty yards. Exposures of gneiss.

Two and a-half miles farther up the river, an exposure of seventy-five feet was seen, the rocks being fine-grained red gneiss, alternating with bands of dark-grey hornblende and mica-schist.

One mile beyond was seen coarse-grained red gneiss, containing large crystals of pink orthoclase and black mica, with dark-grey quartz, for one hundred yards.

The next exposure occurred two miles further up the river, and consisted of fine-grained dark-grey gneiss, composed of light-grey orthoclase, black mica and a small quantity of quartz. Dip S. 60° E. $<60°$.

Then, two miles to coarse-grained red gneiss, some of which exhibits no signs of bedding, and resembles the granite. The length of this exposure is about two hundred yards. Two miles beyond is fine-grained grey and red gneiss, the former predominating. Dip N. 60° W. < 50.

No outcrops now occur on the river for twenty-one miles, when the following fine exposure was seen. The section, in ascending order, is as follows:—Thirty feet, dark-grey gneiss, containing masses of almost pure pink orthoclase; then thirty feet of coarse red gneiss, composed chiefly of red orthoclase and grey quartz, resembling graphic granite. Many dark-red garnets, as large as peas, are scattered through this rock in bands. Above this is twenty-five feet of fine-grained grey

gneiss, highly micaceous; and then twenty feet of highly quartziferous gneiss, containing quantities of large orthoclase crystals and a little mica. Above this, fifty feet of alternate bands of red and grey gneiss, varying in color with the quantity of mica present, and from the same cause changing in texture, being fine-grained when an excess of that mineral is present. The dip of these bands is S. 40° E. <60°.

The next exposure occurs about four miles beyond the last, and two miles below the first fall. The rocks consist of red and grey gneiss. Similar exposures, having a dip N. 60° W. <45°—60°, are seen at the falls. On the shore, immediately below the fall, are large beds of iron and garnet sands. These have been washed there by the strong eddy in river at this point, having been carried down from some point farther up the stream, where they are formed by the disintegration of the iron-bearing gneisses subsequently mentioned. Red and grey gneisses were seen, at distances of one, two, four and nine miles above the falls, having a dip of S. 60° E. < 70°.

At the foot of the four-mile portage, and fourteen miles above the first fall, was seen a yellowish-grey gneiss, composed chiefly of quartz and mica, and covered with a film of black oxide of iron about one-eighth of an inch thick. This rock is a decomposition product of the ordinary red gneiss, charged with grains of magnetic iron, and has been formed in the manner described in a subsequent paragraph. A short distance beyond, these rocks were found highly charged with magnetite in small grains. Dip N. 20° W. <75°. Six miles beyond, greyish and pink gneiss, apparently holding much iron outcrops, with a strike S. 70° W. Three miles farther, dark red coarse-grained gneiss; strike S. 50° W.

Iron.

At a small fall, three and a-half miles above the last exposure, is a red gneiss, weathering a pale buff, and highly charged with magnetic iron in lenticular beds and small grains. The beds vary in width along their course from half an inch to eight inches.

At the second small lake on the ten-mile portage, an exposure of coarse-grained red granitoid gneiss was seen. On the fourth lake occurs fine banded red gneiss. Dip S. 45° E. <45°. Interstratified with these are beds of a micaceous iron ore, seemingly of great extent. These beds are not pure, but in the form of a gneiss, composed of quartz, mica and hornblende, with a very large percentage of iron ore.

On the last lake of the portage, besides the red gneiss, loose angular blocks of a dark greyish-blue trap, containing minute crystals of dark green hornblende and grains of dark grey quartz, were seen scattered along the shore, and had evidently not travelled far. Considerable beds of the iron-bearing rocks are also seen on the lake, interstratified with the red gneiss.

Trap.

The next exposure occurs on the river at the end of the ten-mile portage, and consists of buff and red gneisses. These buff rocks are a decomposition-product of the red, the feldspar being dissolved out, leaving a friable sandstone, consisting of quartz and magnetic grains, these being probably the source of the beds of iron-sands found along the river and coast.

Similar exposures were seen at intervals along the shores of Lake Natuakimin.

Three miles up the river beyond this lake, and fifty-eight miles from the first fall, occurs an outcrop of pink crystalline limestone, coarsely granular in structure, and containing crystals of mica and sphene.

A short distance beyond is a dark grey stratified dioritic rock, composed chiefly of quartz hornblende and triclinic feldspar, and just beyond pink crystalline limestone again occurs, and here holds crystals of a bluish-grey plageoclase.

Labradorite.

No exposures now occur on the river for thirteen miles, to where the stream turns eastward and breaks through the Labradorite hills for six miles to Lake Pipmuakin. The first rock here seen was a bluish-grey massive plageoclase feldspar, containing large crystals of the same mineral. This is followed by a dark bluish-black feldspar rock, with hornblende. Half a mile beyond, a gneiss, made up of plageoclase quartz and mica, occurs, and is followed by coarse-grained dark plageoclase rock, weathering grey, and containing grains of magnetic iron ore.

One mile from Lake Pipmuakin was seen a dark grey triclinic feldspar rock, weathering to a light yellow. Dip S. 70° E. <70°. At this point a conspicuous fault occurs on the south side of the river; the hill is broken through its centre, and the east side has subsided fully thirty feet.

The above rocks are probably part of the area of plageoclase rock traced by Mr. F. Adams to the north and east of Lake St. John. They continue about three miles along the north-west shore of Lake Pipmuakin, where they give place to a coarse-grained red gneiss, and just beyond a dark grey orthoclase gneiss. The contact between the plageoclase rocks and the orthoclase gneisses was not seen, being covered with drift.

One mile beyond the last exposure is a light grey quartzite, containing considerable quantities of black mica, with a strike of N. 10° W. This is followed in two miles by dark grey fine-grained gneiss, composed chiefly of quartz and black hornblende, with orthoclase. Dip N. 40° E. <75°. At the entrance of the north-west bay was seen red and grey gneiss, changing in colour with the different proportions of quartz, hornblende and orthoclase. Similar exposures occur on the small islands in the bay and at the mouth of the Pipmuakin River.

Probable Huronian Conglomerate.

Many boulders of a conglomerate were seen strewn along the shore of the lake, having a matrix of crystalline limestone, holding gneiss pebbles. No rock exposures were observed along the Pipmuakin River, although near the point where the portage route leaves it for the Manouan River, loose angular blocks of a white crystalline limestone are scattered over the surface, and evidently not much travelled.

On the third and fourth lakes of the Manouan portage, the ordinary red and grey gneisses, composed of quartz, hornblende and orthoclase, were seen, having a dip S. 60° W. $<70°$.

The next exposure occurs on the Manouan River, a short distance above the point where we entered it. The rock here seen was a dark green hornblendic gneiss, holding considerable quantities of magnetic iron. Dip S. 60° E. $<70°$. Exposures of similar gneiss occur along the river as far as the portage to Lake Manouan. In these the darker varieties, containing large proportions of hornblende, predominate, and the greater number show signs of magnetite present.

On the fifth lake of the Lake Manouan portage route, a greyish-green crystalline limestone, containing large crystals of mica and

Mica.

hornblende, was found interstratified with the red gneiss. Some of the mica crystals found on the surface were six by four inches in diameter, and quite fit for purposes of commerce. The limestones were seen at intervals along the route for a distance of three miles. Beyond this, no exposures occur until Lake Manouan is reached.

On the north side of the lake, three exposures of dark grey hornblendic gneiss were seen, having a dip N. 10° E. $<60°$. At the first lake on the portage route from Lake Manouan to the Peribonka River, an outcrop of red fine-grained gneiss occurs. Dip S. 30° W. $<40°$.

Nothing further was seen until the inlet of Lake Onistagan, on the Peribonka River, was reached, the rock here being dark grey hornblende-gneiss. Fifteen miles farther up the river is coarse-grained red and grey gneiss, containing a large proportion of quartz. Strike N. 30° W. At each of the small rapids beyond this point, light grey gneiss, composed chiefly of quartz and hornblende, with small quantities of orthoclase, was seen.

From the Peribonka River to Lake Mistassini, but few exposures were observed, as the country at the time we traversed it was covered with snow, which probably hid some of the few outcrops occurring.

The last exposure of gneiss was seen at the Crooked Lake, on the Temiscamie River, beyond the Height of Land; the next exposure being Cambrian limestone, on Lake Mistassinis, so that the junction of the two formations lies between these points.

To the westward, on the Ashouapmouchouan and Mistassini Rivers, similar Larentian rocks extend all the way from Lake St. John to the

Height of Land, and are described in the Reports of the Geological Survey 1870-71 and 1871-72, by Messrs. Richardson and McOuat, respectively.

From these observations it may be concluded that, with the exception of the comparatively small areas of Cambro-Silurian rocks in the neighborhood of Lake St. John, and perhaps similar small areas at other points not yet explored, all the rocks between the Gulf of St. Lawrence and the Height of Land are of Laurentian age. And these rocks probably extend far beyond to the shores of Hudson Straits, occupying the greater part of the Labrador peninsula, with but few areas of newer rock overlying. On the west side of Lake Mistassini, the coarse grained red gneiss, composed of quartz, orthoclase, mica and hornblende, appear with a general strike of N. 30° E. The space between Crooked Lake and this side being overlaid by the Cambrian limestones which extend to the western shore of the lake. On the Rupert River, the coarse-grained red gneiss predominates over the finer-grained varieties. Extent of Laurentian rocks.

At the junction of the Marten and Rupert Rivers, and for some distance below, a darker gneiss, containing larger quantities of dark green hornblende, appears. In the river, at the first portage of "The Fours," a dyke of dark greyish-green dioritic trap, over twenty yards wide, running S. 70° W., penetrates the red gneiss and holds gneissic fragments near the plane of junction. Trap dyke.

Farther down the river, the exposures are fewer; the last is at the House Rapid, one mile above Rupert House and consists of the common red gneiss. Strike W. 10° S.

HURONIAN.

A series of rocks similar to the epidotic and chloritic slates of the Shickshock Mountains and the Eastern Townships, is seen first about forty miles south-west of the southern extremity of Lake Mistassini. These rocks have been fully described by Mr. Richardson in the Geological Survey Report for 1870-71, from which the following is an extract:— Richardson's report.

"This series was first observed at the north end of Lake Abatagomaw. Thence it occupies the country along the line examined, to and along Lake Wakinitche, including Lake Chibogomou and the lakes and portages between it and Abatagomaw [large lakes lying south-west of Mistassini]. The last of it was seen at about two miles beyond the outlet of Lake Wakinitche, nearly four miles in a straight line from where it was first observed on Lake Abatagomaw. As already stated, the rocks of this series are met with almost immediately

succeeding the Laurentian, near the north end of Lake Abatagomaw. Beyond this, they are well seen in a narrow bay running for several miles in a direction nearly east, where they occur both on the shore of the bay and on islands. The rocks here are green chloritic slates. In some places they contain crystals of hornblende, and are occasionally interstratified with dolomitic beds, weathering brown. The dip along this stretch is from N. 31° W. to N. 3° E. $<$44° to 68°. On the first portage beyond this bay there are considerable exposures of flattened spheroidal or reniform masses, from a few inches to upwards of a foot in diameter. They are made up of an indurated greenish and purplish argillaceous rock, which is jaspery in its texture. When sections of these spheroids have been exposed to the weather, they present a concentric arrangement of various shades of color, becoming lighter towards the centre. The strike of these rocks is N. 61° E. and S. 61° W. To the end of the second portage, the rock is a greenish chloritic slate, becoming, in places, epidotic and dioritic, the latter variety assuming a reniform structure, and holding, between the concentric layers a soft dark greenish mineral, resembling serpentine. The next exposure is a little beyond the entrance of Lake Chibogomou, and is the only one met with for about four miles, on the main west shore, or on the islands immediately to the eastward. It is a quartzose feldspathic rock, with films of a greenish chloritic mineral. The feldspar is yellowish and the quartz greenish in hue. On an island about seven miles from the entrance to the lake, the rock is very similar, except that the chloritic mineral above mentioned occurs only in spots. Between the last two exposures, but somewhat to the eastward of them, there are two islands, composed of a yellowish micaceous granite. For the next four miles, as far as observed, on the north-east side of the lake and the islands adjacent, the rocks are a light grey and yellowish felsite, with quartz and minute scales of mica or talc. In some places these are associated with a green dioritic rock, in small bands, of from one to four feet wide, the strike of which is S. 33° E. and N. 33° W. If this banding is due to bedding, which is doubtful, it is the only indication of lines of stratification observed thus far on the lake.

Magnetic iron.

"The next point at which the rock is seen on the same side is just before reaching Paint Mountain. Here it is a green chloritic rock, weathering to greyish green, and holding considerable quantities of magnetic iron ore disseminated in grains and crystals. Still closer to Paint Mountain, on the shore, the rocks are green chloritic slate, with no well-defined bedding. Here the yellow sulphuret of copper, which is described farther on, occurs. These rocks are also more or less charged with fine-grained iron pyrites, for a distance of about

Copper.

a mile, to a point immediately below Paint Mountain, which rises above the lake, in a short distance back, to a height of 250 feet. In one place, there is a depression running up the mountain from the lake, thirty feet wide, filled with drift. The strike of this depression is S. 61° W. and N. 61° E. On Sorcerer's Mountain, which rises, on the south-east, to a height of 425 feet above the lake, the rock is green chloritic slate, with small specks of iron pyrites disseminated irregularly through it. In the narrows of the north-east end of the lake, the rock is a conglomerate and breccia. In some parts, it is made up of small fragments of the rocks already described; consisting of yellowish feldspar and quartz, green chlorite, serpentine, and epidote; while in others, the pieces are from a few ounces to one hundred pounds in weight. Large expanses of conglomerate are likewise entirely composed of rounded fragments of Laurentian gneiss of grey and red colors, the latter predominating. Other exposures show a conglomerate made up of angular and rounded fragments from an ounce to a ton weight, in a matrix of fine material of the same kind. These conglomerates are succeeded by serpentines and associated rocks, which make their appearance immediately to the west of the first portage leading from the lake. About 200 yards west of the portage-road, a cone-shaped hill, which rises over the waters of the narrows about one hundred and sixty feet, is entirely composed of serpentine. This rock is traced, on one side, to the portage, and on the other it is supposed to form part of Juggler's Mountain, which is about 400 feet high, and is about two miles distant, bearing S. 41° W. On the highest part of the cone referred to there is a blackish limestone, about one foot thick, interstratified with serpentine. Dr. Hunt, while examining these rocks, had a portion of the limestone sliced for examination under the microscope, which revealed a structure resembling that of some coral. The serpentines, which are dark colored, opaque, and contain much disseminated magnetic iron, yield by analysis considerable portions of chrome and traces of nickel. On an island opposite the portage, the rock is blackish-blue hard slate, rarely with what appear to be small grains of whitish feldspar. On the various portages and small lakes passed over from this point to Lake Wakinitche, the only rock seen is chloritic slate. The same remark applies also to the lake itself, from its south-west end, along the south-east side, to within six miles of its outlet. In this last distance, and for a mile beyond the outlet, only conglomerate rocks are seen. These resemble the two varieties already described. On the north-west side of the lake, about the middle, these rocks rise to a height of 150 or 200 feet, forming a bare escarpment, extending for about four miles; and, on the same side, near the outlet, Wakinitche

Conglomerate.

Mountain, which is entirely composed of them, rises about 350 to 400 feet high, for the most part bare and rocky, and extending along the margin of the lake for nearly three miles. The fragments in the conglomerates in the last localities are chiefly of Laurentian rocks, and the enclosed masses are often many tons in weight. In some parts, without close examination, the conglomerate might be mistaken for Laurentian gneiss. In many parts of this hill considerable exposures of red shale are met with, as well as grey and chocolate-brown sandstones made up of fine grains of reddish feldspar and white quartz. Although lines of deposition were observable in these sandstones, I could trace no regular line of strike or dip."

On the Little Perch River, which flows into Chabestachuan Bay, and three miles from its mouth, Mr. McOuat met with some small exposures of a reddish feldspathic rock, apparently of a brecciated character, with calcareous seams, and showing a considerable amount of a dull green steatitic mineral. This rock occupies, as nearly as possible, the position in which one might expect to meet with Mr. Richardson's group, and may represent some of the conglomerates of that group. Nothing was seen at all like the chloritic slates of Lakes Wakinichi and Chibogomon. The above band is not over one mile wide, coming in between the Laurentian gneiss and the Cambrian limestone.

Little Perch River.

Farther to the eastward, on the Temiscamie River, I failed to find any trace of these rocks, and am of the opinion that the belt does not extend that far to the eastward.

The following is the description of the economic minerals found in these rocks, as given by Mr. Richardson :—

Copper.

"*Copper.*—Copper pyrites has already been mentioned as occurring in the neighborhood of Paint Mountain, on Lake Abatagomaw. At a point a little to the south-west of the mountain, on the lake shore, this ore is met with in specks, together with stains of the green carbonate, but no well-defined bed or vein was observed. The rock a green, slightly calcareous, chloritic slate. These indications of copper are seen for nearly half-a-mile north-easterly along the lake shore, to another point, where a bed or vein, two feet thick, containing copper-pyrites, is seen in chloritic rock for about twenty feet. Its strike is N. 31° E., and S. 31° E., the underlie not being determinable. The portion of the vein exposed would probably yield four or five per cent. of copper throughout, while parts of it might produce ten or twelve per cent. For about three-quarters of a mile farther along the shore, specks of the yellow sulphuret and the green carbonate of copper are met with wherever the rock appears. At the end of this distance, and just under Paint Mountain, the rock is largely charged with

fine-grained iron-pyrites and specks of yellow sulphuret, in a yellowish quartzose gangue. Here the iron-pyrites constitutes as much as fifteen or twenty per cent. of the rock, while along the whole of the distance above described, about one and a-quarter miles, it is never absent, though occurring in small quantities. At the last mentioned place is the depression before described. As before stated, it is filled with drift, and no rock is seen in it; but from the quantities of iron and copper-pyrites met with in the rock on both sides of it, it is quite possible that under the drift a valuable deposit of copper ore may exist.

"*Iron.*—About half-a-mile south-west of the first mentioned copper ore, and near the lake shore, there is a deposit of magnetic iron ore in chlorite slate; its breadth is fifty feet, and it is seen on its strike, which is S. 65° W., and N. 65° E., about 200 paces. The ore occurs in crystalline lumps and grains throughout the rock. The whole fifty feet would probably yield an average of from fifteen to twenty per cent. of iron. Iron.

"*Ochre.*—The only place this was observed was in the north-east part of Paint Mountain, where a small deposit was met with about half way up the mountain, which probably derives its name from the presence of this ochre or paint." Ochre.

CAMBRIAN.

The limestones found on Lakes Mistassini and Mistassinis, owing to the absence of any fossil remains, have been referred to this horizon on account of their lithological resemblance to Cambrian rocks of the east side of James Bay.

These rocks form the basin of the two lakes, and extend but little beyond their shore line. The south-west boundary is at the end of Abatigoush Bay, where they succeed the Huronian rocks seen on Lake Wakiniche, the contact of the formations being concealed by drift. Area.

Following the western limit, we next find the limestones in contact with, and lying unconformably on, the Laurentian gneiss, on Ponichuan Bay, at the place where the bay narrows. The boundary then follows along the north-west shore of the lake to the north-east end, and I think continues in the same course to a low range of hills, which lies about ten miles beyond the end of the lake.

Sweeping eastward along the base of these hills, the rocks extend beyond the south-west side of Lake Mistassinis, and are seen to occupy the whole of that shore.

Mr. Bignell describes the limestones as occurring several miles on the Temiscamie River, from its inlet to Lake Mistassinis.

These rocks have a strike parallel, approximately, to the length of the lakes, the dip being to the south, and changing to eastward at the southern end of the lake, with an angle varying from 4° to 10°. The lower beds resting unconformably on the gneiss, at the western side of Lake Mistassini, are made up of a dark bluish-grey limestone, holding concretionary masses of dark blue chert, with thin bands of black argillaceous shale. Above this are thin beds of light blue fine-grained dolomitic limestone, weathering yellow, interbedded with thin layers of a greyish, coarse, gritty limestone, containing large quantities of sand. Next, a ten-feet bed of massive light blue, pure limestone, very compact and hard. This rock is traversed by deep vertical cracks, probably due to the action of frost. Overlying this bed are thinner ones of the same character, intermingled with beds of coarse, grey, silicious limestone, full of grit.

Strike.

The top layer is a limestone conglomerate, made up of limestone pebbles embedded in a sandy matrix.

The thickness of the whole series does not exceed one hundred feet.

Although closely examined, none of the above beds gave any evidence of fossil remains, the supposed fossils found by Mr. Richardson having, on closer examination, proved to be only mineral concretions.

Superficial Deposits.

Owing to the absence of any considerable elevations near the sea coast, and to the shallow valleys cut by the rivers, but little information was obtained relating to the drift deposits.

Where good rock exposures occurred, they were generally formed by having the usual covering of vegetable matter burnt away; and the heat occasioned by this, along with subsequent rains, has been sufficient to obliterate any traces of glacial striation. Thus the direction of the drift can only be arrived at by a study of the travelled boulders. In the vicinity of Lake Mistassini, no rounded boulders of limestone were met with in directions to the east and north-west of the lake, and the probability is that the drift there was from north-east to south-west. On the Peribonka River, boulders of green chloritic and epidotic rocks were seen. These are supposed not to have come from the rocks of Lake Wakiniche, but from a similar patch of Huronian rocks, which, I am told, occurs near the head-waters of the Outard and Maniquagan Rivers, to the north-east of the place where the boulders were seen.

No exposures of boulder-clay were seen, although the surface of the whole country is thickly covered with rounded, travelled boulders, both great and small, showing the action of ice.

As before mentioned, on the Betsiamites River, at intervals along its shores, as far as the first fall, beds of blue clay were seen overlaid by sand. In places the exposures of these showed a thickness of thirty feet of clay, and the beds were greatly crumpled and folded.

The surrounding country here is too low to afford good illustrations of terraces and none were seen. Beyond the first fall, and as far as Lake Mistassini, the banks of the rivers and lakes passed are low, and no good cuttings in the drift were seen.

Three miles to the north of the Hudson Bay post on Lake Mistassini, is a sand-bank forty feet high, without signs of stratification, and containing quantities of coarse gravel. Similar exposures were also seen near the Big Narrows.

On the Rupert River, nothing but sand was seen until the Oatmeal Fall was passed. Below this, the river banks are cut out of a blue clay, showing stratification and overlaid by sand. These clays often show in exposures a thickness of thirty feet, and are very free from boulders.

APPENDIX I.

LIST OF BIRDS COLLECTED AT LAKE MISTASSINI, BY JAS. M. MACOUN, 1885.

Hylocichla mustelina, Baird. Robin. Common. Breeds. May 8th.

Hylocichla Unalashkae, var. *Pallasi*, Ridgw. Hermit Thrush. Not rare. Breeds. May 23rd.

Regulus calendula, Licht. Ruby-crowned Kinglet. Common. Breeds. May 11th.

Parus atricapillus, L. Chickadee. During winter.

Anorthura (Troglodytes) hyemalis, Coues. Winter Wren. During winter.

Helminthophaga peregrina, Baird. Tennessee Warbler. Not rare. Breeds. June 13th.

Dendroeca aestiva, Baird. Yellow-bird. Common. Breeds. May 30th.

Dendroeca maculosa, Baird. Magnolia Warbler. Not rare. Breeds. May 25th.

Dendroeca striata, Baird. Black-Poll Warbler. Not rare. Breeds. June 15th.

Siurus nævius, Coues. Water Thrush. Breeds here. Common. May 19th.

Wilsonia pusilla Bp., Green. Black-capped Yellow Warbler. Not rare. Breeds. May 30th.

Tachycineta bicolor, Caban. White-bellied Swallow. Common. Breeds. May 10th.

Ampelis cedorum, Baird. Cedar Bird. Rare. Breeds.

Pinicola enucleator, Vieill. Pine Grosbeak. During winter.

Loxia leucoptera, Gm. White-winged Cross-bill. During winter.

Œgiothus linaria, Caban. Common Red-poll. During winter.

Plectrophanes nivalis, Meyer. Snow Bunting. Leave about May 10th.

Melospiza fasciata, Scott. Song Sparrow. Common. Breeds. May 23rd.

Junco hyemalis, Scl. Black Snow-bird. All year, and breeds.

Spizella montana, Ridgw. Tree Sparrow. Common. Breeds. May 15th.

Zonotrichia albicollis, Bon. White-throated Sparrow. Common. Breeds. May 20th.

Zonotrichia leucophrys, Swains, W. Common. Breeds. May 20th.

Molothrus ater, Gray. Cow-bird. Common. Breeds. May 14th.

Scolecophagus ferrugineus, Sw. Rusty Grackle. Breeds. Common. May 14th.

Corvus corax, var. *carnivorus*, Bartr. Raven. One specimen. May 30th.
Perisoreus Canadensis, Bon. Whiskey Jack. All year. Breeds.
Empidonax flaviventris, Baird. Yellow-bellied Fly-catcher. Common. Breeds. June 2nd.
Chordeiles popetue Baird. Night Hawk. Not rare. Breeds. May 29th.
Ceryle alcyon, Boie. King-fisher. Common. Breeds. May 14th.
Picus pubescens, Linn. Downy Wood-pecker. During winter.
Colaptes auratus, Sw. Golden-winged Woodpecker. Not common. Breeds. June 10th.
Surnia funerea, Rich & Sw. Day-owl. Rare. During winter.
Pandion haliaetus, var. *Carolinensis*, Gmelin. Fish-hawk. Not common. July 10th.
Canace Canadensis, Bon. Spruce Partridge. Common all year.
Bonasa umbellus, Steph. Partridge. Common all year.
Lagopus albus, Aud. Willow Ptarmigan. Appear about Oct. 25th. Depart about May 1st.
Œgialitis semipalmatus, Caban. Semi-palmated Ring-necked Plover. One specimen. May 29th.
Totanus melanoleucus, Vieill. Greater Yellow-legs. A single pair. May 7th.
Totanus flavipes, Vieill. Yellow-legs. A single pair. August 10th.
Rhyacophilus solitarius, Cass. Solitary Sand-piper. Common. Breeds. May 23rd.
Nyctiardea grisea, var. *nævia*, Allen. Night Heron. A single specimen. Aug. 6th.
Bernicla Canadensis, Boie. Canada Goose. Passed May 2nd.
Anas obscura, Gmel. Dusky Duck. Passed May 20th.
Clangula (Glaucium) Americana, Bonap. Golden-eye. Passed. May 3rd.
Somateria spectabilis, Boie. King-Eider Duck. One specimen, Not known before.
Œdemia Americana, Sw. & Rich. Sea-coot. Passed. May 15th.
Œdemia perspicillata, Flem. Surf Duck. Passed. May 28th.
Mergus merganser, var. *Americanus*, Cassin. Sheldrake. Not rare. Breeds. June 1st.
Mergus serrator, Linn. Red-breasted Sheldrake. Not rare. Breeds. May 11th.
Larus Delawarensis, Ord. Ring-billed Gull. Common. Breeds. May 11th
Sterna Forsteri, Nutt. Forster's Tern. Common. Breeds. June 1st.
Colymbus torquatus, Brünn. Great Northern Diver. Common. Breeds. May 14th.
Colymbus arcticus, Linn. Black-throated Diver. Not common. Breeds. June 3rd.

NOTE.—In the above list, the date following each species refers to the day upon which it was first shot, unless otherwise specified.

APPENDIX II.

List of plants collected at Lake Mistassini, Rupert River and Rupert House, by Jas. M. Macoun, 1885.

The first column in the following list contains those species found at Lake Mistassini, the second, the species growing along the Rupert River and not noted at Mistassini, and the third, the species growing at Rupert House and not seen either at Mistassini or along the Rupert.

Nos.		Mistassini.	Rupert River.	Rupert House.
	RANUNCULACEÆ.			
1	Anemone parviflora, Michx	*		
2	" dichotoma, Linn		*	
3	Thalictrum dioicum, L	*		
4	Ranunculus abortivus, L			*
5	" Cymbalaria, Pursh			*
6	" Pennsylvanicus, L	*		
7	" recurvatus, Poir	*		
8	Caltha palustris, L			*
9	Coptis trifolia, Salisb	*		
10	Actæa spicata L. var. rubra, Ait	*		
	NYMPHÆACEÆ.			
11	Nuphar advena, Ait	*		
	SARRACENIACEÆ.			
12	Sarracenia purpurea, L	*		
	FUMARIACEÆ.			
13	Corydalis glauca, Pursh		*	
	CRUCIFERÆ.			
14	Nasturtium palustre, D. C	*		
15	Cardamine hirsuta, L	*		
16	" pratensis, L	*		
17	Capsella Bursa-pastoris, Moench	*		
18	Thlaspi arvense, L			*
	VIOLACEÆ.			
19	Viola cucullata, Ait	*		
20	Viola canina L. var. sylvestris, Reg	*		

No.		Mistassini.	Rupert River.	Rupert House.
	CARYOPHYLLACEÆ.			
21	Silene noctiflora, L			*
22	" Armeria, L			*
23	Arenaria Michauxii, Hook	*		
24	Stellaria media, Smith			*
25	" borealis Bigel. var. alpestris, Gray	*		
26	" humifusa, Rottb	*		
27	" longipes, Goldie			*
28	Cerastium arvense, L		*	
	GERANIACEÆ.			
29	Geranium Carolinianum, L		*	
	RHAMNACEÆ.			
30	Rhamnus alnifolius, L'Her	*	*	
	LEGUMINOSÆ.			
31	Vicia Cracca, L			*
32	" Americana, Muhl			*
	ROSACEÆ.			
33	Prunus Pennsylvanica, L	*		
34	Spiræa salicifolia, L	*		
35	Geum macrophyllum, Willd	*		
36	" rivale, L	*		
37	" strictum, Ait		*	
38	Fragaria Virginiana, Ehrh	*		
39	Potentilla Norvegica, L	*		
40	" arguta, Pursh	*		
41	" Anserina, L	*		
42	" fruticosa, L	*		
43	" tridentata, Ait	*		
44	" palustris, Scop	*		
45	" Pennsylvanica, L			*
46	Rubus Chamæmorus, L	*		
47	" triflorus, Rich	*		
48	" arcticus, L	*		
49	" " var. grandiflorus, Ledeb	*		
50	" strigosus, Michx	*		
51	Rosa Sayii, Wat	*		
52	Pyrus Americana, D C			
53	Amelanchier Canadensis, T. & G., var. oblongifolia, T. & G	*		
54	" " var. oligocarpa, T. & G	*		
	SAXIFRAGACEÆ.			
55	Mitella nuda, L	*		
56	Parnassia palustris, L			*
57	Ribes lacustre, Poir	*		
58	" prostratum, L'Her	*		
59	" rubrum, L	*		
60	" oxycanthoides, L	*		

No.		Mistassini.	Rupert River.	Rupert House.
	DROSERACEÆ.			
61	Drosera rotundifolia, L.	*		
62	" intermedia Drev. & Hayne, var. Americana, D C.	*		
	HALORAGEÆ.			
63	Hippuris vulgaris, L	*		
	ONAGRACEÆ.			
64	Circœa alpina, L			*
65	Epilobium angustifolium, L.	*		
66	" palustre L. var. lineare, Gr.	*		
67	" tetragonum, L.	*		
	UMBELLIFERÆ.			
68	Sanicula Marilandica, L.	*		
69	Heracleum lanatum, Michx	*		
70	Archangelica atropurpurea, Hoffm			*
71	Cicuta maculata, L		*	
	ARALIACEÆ.			
72	Aralia hispida, Michx	*		
73	Aralia nudicaulis, L	*		
	CORNACEÆ.			
74	Cornus Canadensis, L.	*		
75	" sericea, L		*	
76	" stolonifera, Michx	*		
	CAPRIFOLIACEÆ.			
77	Linnæa borealis, Gronov	*		
78	Lonicera involucrata, Banks	*		
79	" cærulea, L	*		
80	Diervilla trifida, Moench	*		
81	Sambucus pubens, Michx	*		
82	Viburnum pauciflorum, Pylaie	*		
	RUBIACEÆ.			
83	Galium triflorum, Michx	*		
84	" trifidum, L.	*		
85	" asprellum, Michx		*	
	VALERIANACEÆ.			
86	Valeriana sylvatica, Rich	*		
87				
88	COMPOSITÆ.			
89				
90	Eupatorium purpureum, L.		*	
91	Solidago lanceolata, L.		*	
92	" Canadensis, L.	*		
93	" bicolor, L. var. concolor, T. & G.		*	

No.		Mistassini.	Rupert River.	Rupert House.
94	Solidago uliginosa, Nutt	*		
95	" macrophylla, Pursh	*		
96	Aster Lindleyanus, T. & G.	*		
97	" puniceus, L		*	
98	" salicifolius, Ait			*
99	" umbellatus, Mill, var. villosus		*	
100	" nemoralis, Ait		*	
101	Erigeron hyssopifolius, Michx	*		
102	" Canadensis, L		*	
103	" Philadelphicus. L		*	
104	Antennaria plantaginifolia, Hook	*		
105	Anaphalis margaritacea, Benth. & Hook	*		
106	Bidens frondosa. L			*
107	" cernua, L			*
108	Achillæa millefolium, L	*		
109	Petasites palmata, Gray	*		
110	" sagittata, Gray			*
111	Senecio aureus, L	*		
112	" " var. obovatus, T. & G	*		
113	" vulgaris, L			*
114	Cnicus muticus, Pursh	*		
115	Hieracium umbellatum, Linn		*	
116	" scabrum, Michx		*	
117	Taraxacum officinale, Web. var. lividum, Koch	*		
118	Lactuca leucophæa, Gray	*		
119	Prenanthes alba, Linn	*		
120	" racemosa, Hook			*
	LOBELIACEÆ.			
121	Lobelia Dortmanna, Linn		*	
122	" Kalmii, L	*		
	CAMPANULACEÆ.			
123	Campanula rotundifolia, L	*		
	VACCINIACEÆ.			
124	Vaccinium Canadense, Kalm	*		
125	" uliginosum, L	*		
126	" Pennsylvanicum, L	*		
127	Oxycoccus vulgaris, Pursh	*		
128	" macrocarpus, Pursh	*		
129	Chiogenes hispidula, T. & G	*		
	ERICACEÆ.			
130	Arctostaphylos Uva-ursi, Spreng	*		
131	Epigæa repens, L	*		
132	Cassandra calyculata, Don	*		
133	Andromeda polifolia, L	*		
134	Kalmia glauca, Ait	*		
135	" angustifolia, L	*		
136	Ledum latifolium, Ait	*		
137	Pyrola secunda, L	*		
138	" rotundifolia, L. var. uliginosa, Gray	*		
139	Moneses uniflora, Gray	*		

No.		Mistassini.	Rupert River.	Rupert House.
	PRIMULACEÆ.			
140	Primula Mistassinica, Michx	*		
141	Trientalis Americana, Pursh	*		
142	Lysimachia stricta, Ait		*	
	LENTIBULACEÆ.			
143	Utricularia vulgaris, L	*		
144	" intermedia, Hayne	*		
145	Pinguicula vulgaris, L			
	APOCYNACEÆ.			
146	Apocynum androsæmifolium, L		*	
	GENTIANACEÆ.			
147	Gentiana serrata, Gunner			*
148	" linearis, Froel		*	
149	Menyanthes trifoliata, L	*		
	BORRAGINACEÆ.			
150	Myosotis verna, Nutt		*	
	SCROPHULARIACEÆ.			
151	Mimulus ringens, L		*	
152	Veronica Americana, Schu	*		
153	Castilleia pallida, Kunth			*
154	Euphrasia officinalis, L			*
155	Rhinanthus Crista-galli, L	*		
156	Pedicularis palustris, L. var			*
157	Melampyrum Americanum, Michx	*		
	LABIATÆ.			
158	Mentha Canadensis, L	*		
159	Lycopus sinuatus, Gray		*	
160	Dracocephalum parviflorum, Nutt		*	
161	Brunella vulgaris, L	*		
162	Scutellaria galericulata, L	*		
163	" lateriflora, L			*
164	Galeopsis Tetrahit, L			*
165	Stachys palustris, L			*
166	Lamium amplexicaule, L			*
	PLANTAGINACEÆ.			
167	Plantago major, L		*	
	CHENOPODIACEÆ.			
168	Chenopodium album, L	*		

No.		Mistassini.	Rupert River.	Rupert House.
	POLYGONACEÆ.			
169	Polygonum aviculare, L	*		
170	" amphibium, L	*		
171	" cilinode, Michx	*		
172	" viviparum		*	
173	" lapathifolium, Ait. var. incanum, Hook		*	
174	Rumex verticillatus, L			*
	SANTALACEÆ.			
175	Comandra livida, Rich	*		
	URTICACEÆ.			
176	Urtica gracilis, Ait		*	
	MYRICACEÆ.			
177	Myrica Gale, L	*		
	BETULACEÆ.			
178	Betula pumila, L	*		
179	" papyracea, Ait	*		
180	" lutea, Michx, f	*		
181	Alnus viridis, D. C	*		
182	" incana, Willd	*		
	SALICACEÆ.			
183	Salix candida, Willd	*		
184	" desertorum, Rich	*		
185	" myrtilloides, L	*		
186	" glauca, L	*		
187	" discolor, Muhl	*		
188	Populus tremuloides, Michx	*		
189	" balsamifera, L	*		
190	Pinus Banksiana, Lamb	*		
	CONIFERÆ.			
191	Abies balsamea, Marsh	*		
192	Picea alba, Link	*		
193	" nigra, Link	*		
194	Larix Americana, Michx	*		
195	Thuja occidentalis, L	*		
196	Taxus baccata, L. var. Canadensis, Gr	*		
197	Juniperus communis, L	*		
	ORCHIDACEÆ.			
198	Habenaria dilatata, Gray	*		
199	" hyperborea, Lindl	*		
200	" obtusata, Rich	*		
201	" rotundifolia, Rich	*		
202	Goodyera repens, R. Br	*		
203	Spiranthes Romanzoviana, Cham	*		

No.		Mistassini.	Rupert River.	Rupert House.
204	Listera cordata, R. Br	*		
205	" convallarioides, Hook	*		
206	Calypso borealis, Salisb	*		
207	Corallorhiza innata, R. Br	*		
208	Cypripedium pubescens, Willd	*		
209	" acaule, Ait		*	
	IRIDACEÆ			
210	Iris versicolor, L	*		
	LILIACEÆ.			
211	Tofieldia glutinosa, Willd	*		
212	" palustris, Huds	*		
213	Streptopus roseus, Michx	*		
214	" amplexifolius, D C	*		
215	Clintonia borealis, Raf	*		
216	Maianthemum bifolium. D C	*		
	JUNCACEÆ.			
217	Luzula spadicea, D. C	*		
218	Juncus alpinus, Vill. var. insignis, Fries	*		
219	" Canadensis, var. coarctatus, Gr	*		
220	" filiformis, L	*		
221	" tenuis, Willd	*		
	ARACEÆ.			
222	Calla palustris, L		*	
	TYPHACEÆ.			
223	Sparganium simplex, Hudson, var. fluitans, Gr	*		
	NAIADACEÆ.			
224	Naias flexilis, Rostk	*		
225	Zannichellia palustris, L	*		
226	Potamogeton gramineus, L. var. graminifolius	*		
227	" " var. heterophyllus, Schreb	*		
228	" pectinatus, L	*		
229	" perfoliatus, L	*		
230	" pusillus, L	*		
231	" rufescens, Schrad	*		
	ALISMACEÆ.			
232	Triglochin maritimum, L	*		
	CYPERACEÆ.			
233	Scirpus validus, Vahl	*		
234	" microcarpus, Presl			*
235	Eriophorum alpinum, L			
236	" vaginatum, L			

No.		Mistassini.	Rupert River.	Rupert House.
237	Carex angustata, Boott			
238	" arctata, Boott			
239	" atrata, L	*		
240	" aurea, Nutt	*		
241	" Buxbaumii, Wahl	*		
242	" canescens, L	*		
243	" " var. alpicola	*		
244	" capillaris, L	*		
245	" chordorhiza, Ehrh	*		
246	" concinna, R. Br	*		
247	" echinata, Murr	*		
248	" flava, L	*		
249	" flexilis, Rudge	*		
250	" lenticularis, Michx	*		
251	" maritima, Vahl			*
252	" miliaris, Michx	*		
253	" Magellanica, Lam	*		
254	" monile, Tuck	*		
255	" Œderi, Ehrh		*	
256	" oligosperma, Michx	*		
257	" polytrichoides, Muhl	*		
258	" scoparia, Schk	*		
259	" teretiuscula, Good		*	
260	" utriculata, Schk	*		
261	" vaginata, Tausch			
	GRAMINEÆ.			
262	Beckmannia erucæformis, Host			*
263	Panicum dichotomum, L		*	
264	Alopecurus geniculatus var. aristulatus, Monro, L		*	
265	Hierochloa borealis, R. & S	*		
266	Stipa Richardsonii, Link		*	
267	Oryzopsis asperifolia, Michx	*		
268	Phleum pratense, L	*		
269	Agrostis scabra, Willd	*		
270	Deyeuxia Canadensis, Beaur	*		
271	" neglecta, Kth	*		
272	Deschampsia atropurpurea, Wahl	*		
273	" cæspitosa, Beaur	*		
274	" flexuosa, L	*		
275	Poa pratensis, L	*		
276	Glyceria Canadensis, Trin		*	
277	" nervata, Trin	*		
278	Bromus ciliatus, L			
279	Agropyrum tenerum, Vasey	*		
280	Hordeum jubatum, L			*
	EQUISETACEÆ.			
281	Equisetum arvense, L	*		
282	" palustre, L	*		
283	" scirpoides, Michx	*		
	FILICES.			
284	Polypodium vulgare, L	*		
285	Pellæa gracilis, Hook			

No.		Mistassini.	Rupert River.	Rupert House.
286	Pteris aquilina, L.			
287	Asplenium viride, Hudson	*		
288	" Filix-foemina, Bernh.	*		
289	Phegopteris Dryopteris, Feé	*		
290	" calcarea, R. Br	*		
291	Aspidium spinulosum var. dilatatum, Gr.	*		
292	Onoclea sensibilis, L.		*	
293	Cystopteris fragilis, Bernh			
294	" montana, Bernh	*		
295	Woodsia Ilvensis, R. Br	*		
296	" glabella, R. Br	*		
297	Osmunda regalis, L.	*		
298	" Claytoniana, L	*		
299	Botrychium Lunaria, Swz	*		•
300	" Virginicum, Swz	*		
301	" ternatum, Swz. var lunarioides, Milde		*	
	LYCOPODIACEÆ.			
302	Lycopodium annotinum, L.	*		
303	" dendroideum, Michx	*		
304	" clavatum, L	*		
305	" complanatum, L	*		
306	" " var. sabinæfolium, Sp	*		

APPENDIX III.

METEOROLOGICAL OBSERVATIONS TAKEN ON THE ROUTE FROM BETSIAMITES TO LAKE MISTASSINI, AND AT THE HUDSON BAY POST, MISTASSINI, AUGUST 8TH, 1884 TO AUGUST, 21ST, 1885.

The readings are those of a mercurial barometer until December 17th, after that date a small aneroid was used.

The temperature is stated in degrees Farenheit.

The force of the wind is estimated according to Beaufort's scale. The proportion of sky covered by clouds is estimated on a scale of 0 to 10, 0 being a cloudless sky, 10 an overcast sky. The character of the clouds is denoted by the usual letters or combinations of letters referring to Howard's classification.

LOCALITY.	Date.	Thermometer.			Barometer.			Maximum.	Minimum.	Wind. Direction.			Wind. Force.			Weather.			Remarks.
	Aug.	7	2	9	7	2	9			7	2	9	7	2	9	7	2	9	
Betsiamites	1				29.43					S.W.						4 C.S.			
"	2																		
"	3																		
"	4																		
"	5																		
"	6																		
"	7																		
"	8	60		52	30.08		30.15			N.W.		0			0	Haze.		Clear.	
13 miles up Betsiamites River	9	51		62	30.28		30.21			0		0			0	0		0	
28 " " "	10	67		61	30.14		29.96			W.		0	1		0	5 K.S.		0	
30 " " "	11	49		67	29.98		29.80			W.		0	1		0	0		0	
1st Fall, Betsiamites River	12	61		63	30.18		30.05			0		0	0		0	0		0	
9 miles above 1st Fall	13	49		59	30.10		29.90			0		0	0		0	Fog.		0	
15 " "	14	61		62	29.90		29.59			0		0	0		0	0		8 S.	
18 " "	15	60		59	29.68		29.64			W.		0	1		0	2 K.S.		0	
29 " "	16	55		65	29.72		29.59			W.		0	1		0	0		0	
29 " "	17	68		68	29.54		29.38			0		W.	0		8	0		0	
29 " "	18	62		54	29.50		28.61			W.		0	3		0	5 S.		0	
29 " "	19	70			28.40		28.70			W.			3			10 S.		N.	
35 " "	20			64	28.83		28.69			W.		0	2		0	0		0	
30 " "	21	77			28.65		28.50			S.W.		0	1		0	5 K.S.		10 S.	
30 " "	22			57	28.57		28.66					W.			1	10 S.		8 K.S.	

55 miles above 1st Fall	23	55		52	28.63		28.43					N.W.				10 S.		10 S.	
70 " "	24	47			28.40		28.00			E.		E.	1		1	N.		N.	
70 " "	25	44		46	28.82		28.87			W.		0	1		0	0		10 S.	
Lake Pipmuakin	26	44		51	28.61		28.50			W.		W.	5		5	N.		5 K.S.	
" "	27	41			28.70		28.68			W.		0	3		0	5 K.S.		0	
70 miles above 1st Fall	28				28.60		28.62			W.		0			0	N.		Fog.	
70 " "	29				28.57		28.49			W.		W.				6 S.		0	
70 " "	30						28.36			E.		0	1		0	N.		5 K.S.	
70 " "	31									E.		E.				N.		N.	
	Sept.																		
70 " "	1															10 S.			
70 " "	2															N.			
70 " "	3															N.	N.	N.	
70 " "	4															0	0	0	
70 " "	5															0	0	0	
39 " "	6															10 S.	10 S.	N.	
39 " "	7															0		0	
60 " "	8															0	0	0	
70 " "	9																		
70 " "	10										E.						0		0	
Lake Pipmuakin	11									E.		W.			4	N.		0	
" "	12								40	N.W.		N.W.	4		4	0		0	
" "	13								37	N.W.		N.W.	4		4	0		0	
" "	14								34	N.W.		N.W.	4		4				
" "	15			37			28.50		27	W.		W.	3		1	0		0	
" "	16	39		49	28.58		28.00		34	E.		E.	1		3	N.	N.	N.	
" "	17	50			28.15		28.19		34	W.		W.	2		1	6 K.S.		5 K.S.	
" "	18	35		31	28.70		28.92		33	N.W.		0	2		0	2 K.S.		0	
" "	19	33		31	29.04		28.88		29	0		0	0		0	Fog.		0	
Pipmuakin River	20	40		42	28.66		28.69		25	E.		W.	1		1	N.	N.	N.	
" "	21	42		46	28.86		28.56		39	0		E.	0		1	Haze.		10 S.	
" "	22	43		29	28.44		28.51		42	N.W.		0	3		0			0	
Manouan Portage	23	25		24	28.66		28.73		22			0			0			0	
" "	24	37			28.62		28.17		21	0		E.	0		1	10 S.	10 S.	N.	
Manouan River	25			38	28.49		28.70			W.		W.	4		3	10 S.		0	
" "	26	34		39	28.98		28.78		31	W.		0	3		0	5 K.S		10 S.	
" "	27	42			28.51		28.16		29			S.				7 S.		N.	
" "	28				28.37		28.25			W.		0	1		0	5 K.S.		10 S.	
" "	29				27.85		28.14			S.W.		S.W.	1		4	N.		N.	
" "	30	43		42	28.53		28.42			W.		E.	4		1	N.		N.	
	Oct.																		
Lake Manouan Portage	1	37		34	28.41		28.58		35	W.		W.	1		3	10 S.		10 S.	Rained in showers all day.
" "	2	30		25	28.82		28.82		27			N.			3	10 S.		0	Aurora (3) last night.
" "	3	20		32	28.75		28.36		14	0		E.			2	Haze.		N.	
Lake Manouan	4	34		38	28.00		28.02		31	W.		W.	2		1	N.		9 S.	About 1 in. snow during night.
" "	5	35		34	28.35		28.40		31	W.		N.	2		1			0	
" "	6	34		37	28.35		28.20		28	N.E.		0	3		0	2 C.			Rn. from 9 to 2, snow till 6.30, (3 inches.)
" "	7	34			28.25		28.25		29	N.		0	1		0	10 S.		0	

LOCALITY.	Date.	Thermometer.			Barometer.			Maximum.	Minimum.	Wind. Direction.			Wind. Force.			Weather.			Remarks.
	Oct.	7	2	9	7	2	9			7	2	9	7	2	9	7	2	9	
Lake Manouan	8	....	....	....	28.10	......	27.96	....	....	0	....	0	0	...	1	10 S.	N.	N.	Snow, 1 inch.
" "	9	....	....	31	28.26	......	28.15	..	....	N.W.	N.W.	N.W.	3	3	3	0	0	0	
" "	10	34	....	34	28.18	......	28.22	....	29	N.W.	N.W.	N.W.	3	3	3	5 K.S.	10 S.	10 S.	
" "	11	....	....	47	27.92	......	27.84	....	....	S.W.	S.W.	S.W.	2-4	2-4	2-4	10 S.	N.	N.	Rained during day.
" "	12	....	....	..	......	......	......	....	32	......	......	......	...	...	...	10 S.	......	......	
" "	13	35	....	33	28.24	......	28.34	....	32	W.	W.	W.	3	3	3	10 S.	10 S.	10 S.	
Peribonka portage	14	34	...	28	28.57	......	28.50	..	21	......	......	......	...	...	...	......	......	......	
Peribonka River	15	24	....	25	28.37	......	28.59	....	23	W.	W.	W.	1	1	1	0	0	0	Aurora (2) last night.
" "	16	27	....	....	28.82	......	27.96	....	....	S.W.	S.W.	S.W.	3	3	3	N.	N.	N.	Snow and rain showers.
" "	17	31	....	27	27.98	....	28.03	....	28	W.	W.	W.	1	1	1	7 S.	......	5 S.	Snow and rain during night.
" "	18	24	...	23	28.13	....	28.38	....	24	W.	W.	0	1	1	0	10 S.	10 S.	Haze.	Snow flurries during the day.
" "	19	25	..	....	28.57	....	28.29	....	18	W.	W.	S.W.	1	1	1	N.	N.	N.	Snow with rain following.
Peribonka branch	20	88	....		28.01	......	28.60	....	24	W.	W.	W.	3	4	2	N.	N.	0	Rain in the morning.
" "	21	19	....	...	28.88	....	28.48	....	19	W.	W.	N.W.	1	1	3	0	0	10 S.	
" "	22	33	....	31	27.90	......	27.98	....	25	W.	W.	W.	1	1	1	N.	N.	10 S.	Rain and snow.
Winter Camp on Branch	23	25	...	21	28.12	......	28.27	....	24	W.	W.	0	1	1	0	N.	N.	10 S.	Snow flurries during the day.
" " "	24	16	22	18	28.42	28.86	28.42	23	12	0	E.	N.	0	1	3	9 S.	N.	N.	Snow. Lake partly frozen over.
" " "	25	22	28	21	28.37	28.88	28.49	30	17	0	0	0	0	0	0	N.	N.	N.	First ptarmigans seen.
" " "	26	02	21	21	28.81	28.83	28.58	26	01	W.	0	0	1	0	0	0	9 S.	N.	Snow during night.
" " "	27	24	29	32	28.35	28.22	28.18	32	1'	S.W.	W.	W.	3	4	1	N.	N.	10 S.	6 inches of snow.
" " "	28	34	33	12	28.02	28.07	28.46	36	82	0	W.	0	0	1	0	N.	N.	0	Rain and snow.
" " "	29	03	18	12	28.72	28.74	28.74	29	03	0	E.	E.	0	2	2	0	N.	5 K.S.	Aurora (1) last night.
" " "	30	04	19	19	28.74	28.65	28.60	....	05	0	0	0	0	0	0	0	N.	N.	2 inches of snow.
" " "	31	18	26	26	28.56	28.49	28.45	....	16	......	......	......	...	...	...	N.	10 S.	10 S.	1 inch of snow during night.
	Nov.																		
1st Lake on Branch	1	24	29	29	28.32	28.24	28.15	30	28	E.	S.E.	S.E.	1	1	1	10 S.	N.	N.	1 inch of snow.
" "	2	19	28	25	28.21	28.28	28.45	30	18	0	0	0	0	0	0	5 K.S.	6 S.	10 S.	1 inch of snow during night.
" "	3	17	22	14	28.60	28.63	28.65	26	16	W.	W.	0	1	1	0	N.	N.	8 K.S.	Light snow flurries.
" "	4	01	20	07	28.80	28.82	28.76	21	08	W.	0	0	1	0	0	Haze.	7 K.S.	Haze.	
" "	5	18	14	11	28.48	28.08	27.92	16	02	N.E.	N.E.	N.E.	1	3	2	N.	N.	N.	4 inches of snow during day.
" "	6	08	17	09	27.89	27.96	28.12	16	08	N.E.	N.W.	N.	3	3	1	10 S.	5 K.S.	0	2 inches of snow during night.
" "	7	01	11	07	28.10	27.92	27.94	11	09	0	N.E.	0	0	3	0	10 S.	N.	N.	Snowing lightly all day.
" "	8	18	17	06	28.24	28.86	28.47	17	13	0	0	0	0	0	0	0	0	0	
" "	9	25	18	18	28.51	28.50	28.46	14	26	0	0	0	0	0	0	0	10 S.	10 S.	
" "	10	19	27	29	28.45	28.89	28.30	80	13	0	0	0	0	0	0	10 S.	10 S.	10 S.	
" "	11	33	84	25	28.18	28.04	28.08	86	29	W.	S.W.	W.	1	3	1	N.	9 S.	N.	Rain and snow all day.
" "	12	18	16	02	28.33	28.38	28.35	18	13	0	0	0	0	0	0	10 S.	2 C.	0	
" "	13	13	25	21	27.99	27.90	28.00	20	04	S.E.	E.	N.E.	1	2	3	N.	N.	N.	1 inch of snow during day.

1st Lake on Branch	14	19	24	24	28.04	......	27.77	25	18	W.	W.	W.	2	5	5	10 S.	N.	N.	2 in. snow. Strong W. gales.
" "	15	10	14	16	28.27	28.36	28.31	17	10	N.	N.W.	0	3	2	0	10 S.	5 K.S.	10 S.	
" "	16	18	25	19	28.15	28.14	28.19	20	06	0	W.	0	0	1	0	5 K.S.	10 S.	10 S.	2 inches of snow.
" "	17	10	07	05	28.15	28.15	28.36	11	06	E.	E.	0	1	1	0	N.	N.	10 S.	
" "	18	04	10	07	28.50	28.50	28.59	11	05	0	N.W.	W.	0	3	2	Haze.	10 S.	10 S.	
" "	19	02	10	13	28.66	28.66	28.65	13	02	0	W.	0	0	2	0	Haze.	5 K.S.	0	
" "	20	27	08	12	28.58	28.52	28.38	13	27	0	W.	0	0	1	0	0	0	N.	
" "	21	14	21	08	28.15	28.15	28.35	23	12	0	W.	N.W.	0	2	3	N.	Haze.	10 S.	3 inches of snow during night.
" "	22	04	10	00	28.62	28.70	28.78	10	03	N.W.	N.W.	0	5	5	0	5 K.S.	7 S.	10 S.	
" "	23	00	10	18	28.58	28.30	27.93	19	09	0	0	S.E.	0	0	3	10 S.	10 S.	N.	Snow and hail, 1 inch.
" "	24	32	05	05	27.43	27.55	27.77	34	24	E.	N.W.	N.W.	3	4	3	N.	N.	0	Rain and sleet all night.
" "	25	19	04	09	27.91	27.90	27.69	13	21	0	N.W.	0	0	1	0	0	Haze.	N.	
" "	26	05	12	11	27.70	27.70	27.78	13	05	0	N.W.	0	0	2	0	5 K.S.	10 S.	N.	1 inch of snow during night.
3rd Lake on Branch	27	14	...	01	27.86	......	27.98	....	14	0	W.	W.	0	2	2	0	3 S 2 SC	0	
" "	28	01	....	10	27.98	......	27.90	....	14	0	0	0	0	0	0	10 S.	10 S.	0	
" "	29	01	09	06	27.80	27.73	27.80	....	24	0	0	W.	0	0	3	9 S.	10 S.	10 S.	
5th Lake on Branch	30	12	00	00	28.08	28.03	28.04	....	13	0	W.	W.	0	3	3	2 S.	10 K.S.	N.	
	Dec.																		
" "	1	06	....	11	28.10	.....	28.02	....	01	W.	S.W.	0	3	3	0	N.	N.	10 S.	Snowing lightly all day.
" "	2	14	22	24	28.04	27.95	27.76	24	09	0	S.W.	S.W.	0	5	5	Fog.	10 S.	10 S.	Mild and overcast, gale S.W.
" "	3	26	31	29	27.65	27.60	27.84	....	24	S.W.	S.W.	S.W.	3	3	1	10 S.	N.	N.	Light snow night and day. ½ in.
" "	4	26	....	05	27.70	.....	28.03	....	26	S.W.	W.	W.	3	4	1	N.	10 S.	9 S.	Light snow and rain.
Cross Lake	5	19	01	11	28.18	28.21	28.32	....	19	0	0	0	0	0	0	0	0	0	
"	6	03	11	15	28.26	28.23	28.20	....	15	N.E.	E.	0	1	2	0	N.	10 S.	10 S.	Light snow betw'n 7 and 8 a.m.
"	7	21	21	23	27.66	27.46	27.38	....	13	N.E.	E.	E.	5	5	2	N.	N.	N.	5 inches snow with gale from E.
"	8	17	20	16	27.56	27.63	27.71	....	15	0	W.	0	0	1	0	10 S.	10 S.	10 S.	
Height of Land	9	09	....	01	27.80	27.93	......	....	09	W.	W.	W.	1	3	1	10 S.	10 S.	......	Light flurries of snow.
Lake Tamiscamie	10	06	....	25	27.99	......	28.48	....	....	0	W.	0	0	1	0	0	0	0	Aurora (3) to-night.
Crooked Lake	11	25	....	07	28.43	......	28.42	....	28	0	E.	0	0	2	0	5 K.S.	Haze.	0	Aurora (1).
Tamiscamie River	12	03	....	04	28.60	......	28.86	....	08	N.W.	W.	0	2	3	0	10 S.	5 S.	0	
Lake Mistassini	13	28	....	04	28.88	......	28.76	....	31	0	0	0	0	0	0	0	0	10 S.	
" "	14	05	....	13	28.78	......	28.67	....	04	W.	S.W.	S.W.	1	3	3	10 S.	N.	N.	Light fall of snow.
" "	15	14	....	10	28.54	......	28.05	....	09	N.E.	N.E.	0	3	3	0	10 S.	N.	0	Heavy snow storm during day.
" "	16	05	....	15	28.62	......	28.45	....	05	N.W.	N.W.	0	5	5	0	0	5 K.S.	0	
" "	17	17	....	....	28.53	......	......	....	22	0	0	0	0	0	0	Haze.	Haze.	Haze.	Thermometers abandoned.
" "	18	....	....	....	......	......	......	....	....	0	0	0	0	0	0	0	0	0	Barometer broken by frost.
Lake Mistassini	19	....	....	....	......	......	......	....	....	0	0	0	0	0	0	0	0	0	Coldest night yet.
" "	20	....	....	....	......	......	......	....	....	E.	E.	E.	1	1	1	10 S.	10 S.	10 S.	Colder than yesterday.
" "	21	....	....	....	......	......	......	....	....	E.	E.	E.	1	1	1	10 S.	N.	10 S.	Light snow in afternoon.
" "	22	....	....	....	......	......	......	....	....	E.	E.	S.	3	4	5	10 S.	N.	10 S.	3 in. snow during night and day.
" "	23	....	....	....	......	......	......	....	....	N.W.	N.W.	N.W.	4	4	4	0	0	0	
H. B. Post Lake Mistassini	24	....	....	28	......	......	......	....	....	0	0	0	0	0	0	0	0	0	
" " "	25	....	....	....	......	......	......	....	....	0	0	0	0	0	0	0	0	0	
" " "	26	....	....	....	......	......	......	....	....	W.	W.	W.	1	2	1	0	0	0	
" " "	27	....	....	....	......	......	......	....	....	W.	W.	W.	1	1	1	0	0	N.	Light snow.
" " "	28	....	....	....	......	......	......	....	....	E.	S.E.	S.E.	2	1	1	N.	10 S.	10 S.	Light snow and rain.
" " "	29	....	....	....	......	......	......	....	....	S.W.	S.W.	S.W.	1	1	1	N.	N.	N.	Raining hard all day.
" " "	30	....	....	....	......	......	......	....	....	W.	W.	W.	3	3	3	0	0	0	
" " "	31	....	....	....	......	......	......	....	....	W.	W.	......	2	3	...	0	3	0	

APPENDIX III.

METEOROLOGICAL OBSERVATIONS TAKEN ON THE ROUTE FROM BETSIAMITES TO LAKE MISTASSINI, AND AT THE HUDSON BAY POST, MISTASSINI, AUGUST 8TH, 1884 TO AUGUST, 21ST, 1885.

The readings are those of a mercurial barometer until December 17th, after that date a small aneroid was used.
The temperature is stated in degrees Farenheit.
The force of the wind is estimated according to Beaufort's scale. The proportion of sky covered by clouds is estimated on a scale of 0 to 10, 0 being a cloudless sky, 10 an overcast sky. The character of the clouds is denoted by the usual letters or combinations of letters referring to Howard's classification.

LOCALITY.	Date.	Thermometer.			Barometer.			Maximum.	Minimum.	Wind. Direction.			Wind. Force.			Weather.			Remarks.
	Aug.	7	2	9	7	2	9			7	2	9	7	2	9	7	2	9	
Betsiamites	1				29.43					S.W.						4 C.3.			
"	2																		
"	3																		
"	4																		
"	5																		
"	6																		
"	7																		
"	8	60		52	30.08		30.15			N.W.		0			0	Haze.		Clear.	
13 miles up Betsiamites River	9	51		62	30.28		30.21			0		0			0	0		0	
28 " " "	10	67		61	30.14		29.95			W.		0	1		0	5 K.S.		0	
30 " " "	11	49		67	29.98		29.80			W.		0	1		0	0		0	
1st Fall, Betsiamites River	12	61		63	30.18		30.05			0		0	0		0	0		0	
9 miles above 1st Fall	13	49		59	30.10		29.90			0		0	0		0	Fog.		0	
15 " "	14	61		62	29.90		29.59			0		0	0		0	0		8 S.	
18 " "	15	60		59	29.68		29.64			W.		0	1		0	2 K.S.		0	
29 " "	16	55		65	29.72		29.59			W.		0	1		0	0		0	
29 " "	17	68		68	29.54		29.38			0		W.	0		3	0		0	
29 " "	18	62		54	29.50		28.61			W.		0	3		0	5 S.		0	
29 " "	19	70			28.40		28.70			W.			3			10 S.		N.	
35 " "	20			64	28.83		28.69			W.		0	2		0	0		0	
39 " "	21	77			28.65		28.59			S.W.		0	1		0	5 K.S.		10 S.	
39 " "	22			57	28.57		28.66					W.			1	10 S.		8 K.S.	

55 miles above 1st Fall	23	55		52	28.63		28.43				N.W.				10 S.		10 S.	
70 " "	24	47			28.40		28.60		E.		E.	1		1	N.		N.	
70 " "	25	44		48	28.82		28.87		W.		0	1		0	0		10 S.	
Lake Pipmuakin	26	44		51	28.61		28.50		W.		W.	5		5	N.		5 K.S.	
" "	27	41			28.70		28.68		W.		0	3		0	5 K.S.		0	
70 miles above 1st Fall	28				28.60		28.62		W.		0			0	N.		Fog.	
70 " "	29				28.57		28.49		W.		W.				6 S.		0	
70 " "	30						28.36		E.		0	1		0	N.		5 K.S.	
70 " "	31								E.		E.				N.		N.	
	Sept.																	
70 " "	1														10 S.			
70 " "	2														N.			
70 " "	3														N.	N.	N.	
70 " "	4														0	0	0	
70 " "	5														0	0	0	
39 " "	6														10 S.	10 S.	N.	
39 " "	7														0		0	
60 " "	8														0	0	0	
70 " "	9																	
70 " "	10								E.						0		0	
Lake Pipmuakin	11								E.		W.			4	N.		0	
" "	12							40	N.W.		N.W.	4		4	0		0	
" "	13							37	N.W.		N.W.	4		4	0		0	
" "	14							34	N.W.		N.W.	4		4				
" "	15			37			28.50	27	W.		W.	3		1	0		0	
" "	16	39		49	28.58		28.00	34	E.		E.	1		3	N.	N.	N.	
" "	17	50			28.15		28.19	34	W.		W.	2		1	6 K.S.		5 K.S.	
" "	18	35		31	28.70		28.92	33	N.W.		0	2		0	2 K.S.		0	
" "	19	33		31	29.04		28.88	29	0		0	0		0	Fog.		0	
Pipmuakin River	20	40		42	28.66		28.69	25	E.		W.	1		1	N.	N.	N.	
" "	21	42		46	28.86		28.56	39	0		E.	0		1	Haze.		10 S.	
" "	22	43		29	28.44		28.51	42	N.W.		0	3		0			0	
Manouan Portage	23	25		24	28.66		28.73	22			0			0			0	
" "	24	37			28.62		28.17	21	0		E.	0		1	10 S.	10 S.	N.	
Manouan River	25			38	28.49		28.70		W.		W.	4		3	10 S.		0	
" "	26	34		39	28.98		28.78	31	W.		0	3		0	5 K.S.		10 S.	
" "	27	42			28.51		28.16	29			S.				7 S.		N.	
" "	28				28.37		28.25		W.		0	1		0	5 K.S.		10 S.	
" "	29				27.85		28.14		S.W.		S.W.	1		4	N.		N.	
" "	30	43		42	28.53		28.42		W.		E.	4		1	N.		N.	
	Oct.																	
Lake Manouan Portage	1	37		34	28.41		28.58	35	W.		W.	1		3	10 S.		10 S.	Rained in showers all day.
" "	2	30		25	28.82		28.82	27			N.			3	10 S.		0	Aurora (3) last night.
" "	3	20		32	28.76		28.36	14	0		E.			2	Haze.		N.	
Lake Manouan	4	34		38	28.00		28.02	31	W.		W.	2		1	N.		9 S.	About 1 in. snow during night.
" "	5	35		34	28.35		28.40	31	W.		N.	2		1			0	
" "	6	34		37	28.35		28.20	28	N.E.		0	3		0	2 C.			Rn. from 9 to 2, snow till 6.30, (8 inches.)
" "	7	34			28.25		28.25	29	N.		0	1		0	10 S.		0	

LOCALITY.	Date.	Thermometer.			Barometer.			Maximum.	Minimum.	Wind. Direction.			Wind. Force.			Weather.			Remarks.
	Oct.	7	2	9	7	2	9			7	2	9	7	2	9	7	2	9	
Lake Manouan	8	....	....	....	28.10	....	27.96	....	....	0	....	0	0	...	1	10 S.	N.	N.	Snow, 1 inch.
" "	9	....	....	31	28.26	....	28.15	..	....	N.W.	N.W.	N.W.	3	3	3	0	0	0	
" "	10	34	....	34	28.18	....	28.22	....	29	N.W.	N.W.	N.W.	3	8	3	5 K.S.	10 S.	10 S.	
" "	11	....	....	47	27.92	....	27.84	....	....	S.W.	S.W.	S.W.	2-4	2-4	2-4	10 S.	N.	N.	Rained dnring day.
" "	12	....	....	..	....	....	....	....	32	....	....	....	...	...	...	10 S.	....	....	
" "	13	35	....	33	28.24	....	28.34	....	32	W.	W.	W.	3	3	3	10 S.	10 S.	10 S.	
Peribonka portage	14	34	...	28	28.57	....	28.50	..	21	....	....	....	...	...	...	....	....	....	
Peribonka River	15	24	....	25	28.37	....	28.59	....	23	W.	W.	W.	1	1	1	0	0	0	Aurora (2) last night.
" "	16	27	....	....	28.32	....	27.96	....	....	S.W.	S.W.	S.W.	3	3	3	N.	N.	N.	Snow and rain showers.
" "	17	31	....	27	27.98	....	28.03	....	28	W.	W.	W.	1	1	1	7 S.	....	5 S.	Snow and rain during night.
" "	18	24	....	23	28.13	....	28.38	....	24	W.	W.	0	1	1	0	10 S.	10 S.	Haze.	Snow flurries during the day.
" "	19	25	..	....	28.57	....	28.29	....	18	W.	W.	S.W.	1	1	1	N.	N.	N.	Snow with rain following.
Peribonka branch	20	38	....	....	28.01	....	28.60	....	24	W.	W.	W.	3	4	2	N.	N.	0	Rain in the morning.
" "	21	19	....	....	28.88	....	28.48	....	19	W.	W.	N.W.	1	1	3	0	0	10 S.	
" "	22	33	....	31	27.90	....	27.98	....	25	W.	W.	W.	1	1	1	N.	N.	10 S.	Rain and snow.
Winter Camp on Branch	23	25	....	21	28.12	....	28.27	....	24	W.	W.	0	1	1	0	N.	N.	10 S.	Snow flurries during the day.
" " "	24	16	22	18	28.42	28.36	28.42	23	12	0	E.	N.	0	1	3	9 S.	N.	N.	Snow. Lake partly frozen over.
" " "	25	22	28	21	28.37	28.38	28.49	30	17	0	0	0	0	0	0	N.	N.	N.	First ptarmigans seen.
" " "	26	02	21	21	28.81	28.83	28.58	28	01	W.	0	0	1	0	0	0	9 S.	N.	Snow during night.
" " "	27	24	29	32	28.35	28.22	28.13	32	1[illegible]	S.W.	W.	W.	3	4	1	N.	N.	10 S.	6 inches of snow.
" " "	28	34	33	12	28.02	28.07	28.46	36	32	0	W.	0	0	1	0	N.	N.	0	Rain and snow.
" " "	29	08	18	12	28.72	28.74	28.74	29	03	0	E.	E.	0	2	2	0	N.	5 K.S.	Aurora (1) last night.
" " "	30	04	19	19	28.74	28.65	28.60	....	05	0	0	0	0	0	0	0	N.	N.	2 inches of snow.
" " "	31	18	26	25	28.56	28.49	28.45	....	16	....	....	....	...	...	...	N.	10 S.	10 S.	1 inch of snow during night.
	Nov.																		
1st Lake on Branch	1	24	29	29	28.32	28.24	28.15	30	28	E.	S.E.	S.E.	1	1	1	10 S.	N.	N.	½ inch of snow.
" "	2	19	28	25	28.21	28.28	28.45	30	18	0	0	0	0	0	0	5 K.S.	6 S.	10 S.	1 inch of snow during night.
" "	3	17	22	14	28.69	28.63	28.65	26	16	W.	W.	0	1	1	0	N.	N.	8 K.S.	Light snow flurries.
" "	4	01	20	07	28.80	28.82	28.76	21	08	W.	0	0	1	0	0	Haze.	7 K.S.	Haze.	
" "	5	13	14	11	28.48	28.08	27.92	16	02	N.E.	N.E.	N.E.	1	3	2	N.	N.	N.	4 inches of snow during day.
" "	6	08	17	09	27.89	27.96	28.12	16	08	N.E.	N.W.	N.	3	3	1	10 S.	5 K.S.	0	2 inches of snow during night.
" "	7	01	11	07	28.10	27.92	27.94	11	09	0	N.E.	0	0	3	0	10 S.	N.	N.	Snowing lightly all day.
" "	8	13	17	06	28.24	28.36	28.47	17	13	0	0	0	0	0	0	0	0	0	
" "	9	25	18	18	28.51	28.50	28.46	14	26	0	0	0	0	0	0	0	10 S.	10 S.	
" "	10	19	27	29	28.45	28.39	28.30	30	13	0	0	0	0	0	0	10 S.	10 S.	10 S.	
" "	11	33	34	25	28.13	28.04	28.08	35	29	W.	S.W.	W.	1	3	1	N.	9 S.	N.	Rain and snow all day.
" "	12	18	16	02	28.33	28.88	28.35	18	13	0	0	0	0	0	0	10 S.	2 C.	0	
" "	13	13	25	21	27.99	27.99	28.00	26	04	S.E.	E.	N.E.	1	2	8	N.	N.	N.	1 inch of snow during day.

1st Lake on Branch	14	19	24	24	28.04	......	27.77	25	18	W.	W.	W.	2	5	5	10 S.	N.	N.	2 in. snow. Strong W. gales.
" "	15	10	14	16	28.27	28.36	28.31	17	10	N.	N.W.	0	3	2	0	10 S.	5 K.S.	10 S.	
" "	16	16	25	19	28.15	28.14	28.19	26	06	0	W.	0	0	1	0	5 K.S.	10 S.	10 S.	
" "	17	10	07	05	28.15	28.15	28.86	11	06	E.	E.	0	1	1	0	N.	N.	10 S.	2 inches of snow.
" "	18	04	10	07	28.50	28.50	28.59	11	05	0	N.W.	W.	0	3	2	Haze.	10 S.	10 S.	
" "	19	02	10	13	28.66	28.66	28.65	13	02	0	W.	0	0	2	0	Haze.	5 K.S.	0	
" "	20	27	08	12	28.58	28.52	28.38	13	27	0	W.	0	0	1	0	0	0	N.	
" "	21	14	21	08	28.15	28.15	28.35	23	12	0	W.	N.W.	0	2	3	N.	Haze.	10 S.	3 inches of snow during night.
" "	22	04	10	00	28.62	28.70	28.78	10	03	N.W.	N.W.	0	5	5	0	5 K.S.	7 S.	10 S.	
" "	23	00	10	18	28.58	28.30	27.93	19	09	0	0	S.E.	0	0	3	10 S.	10 S.	N.	Snow and hail, 1 inch.
" "	24	32	05	05	27.43	27.55	27.77	34	24	E.	N.W.	N.W.	3	4	3	N.	N.	0	Rain and sleet all night.
" "	25	19	04	09	27.91	27.90	27.69	18	21	0	N.W.	0	0	1	0	0	Haze.	N.	
" "	26	05	12	11	27.70	27.70	27.78	13	05	0	N.W.	0	0	2	0	5 K.S.	10 S.	N.	1 inch of snow during night.
3rd Lake on Branch	27	14	...	04	27.86	......	27.98	....	14	0	W.	W.	0	2	2	0	3 S 2 SC	0	
" "	28	01	....	10	27.98	......	27.90	....	14	0	0	0	0	0	0	10 S.	10 S.	0	
" "	29	01	09	06	27.80	27.73	27.80	....	24	0	0	W.	0	0	3	9 S.	10 S.	10 S.	
5th Lake on Branch	30	12	00	00	28.08	28.03	28.04	....	13	0	W.	W.	0	3	3	2 S.	10 K.S.	N.	
	Dec.																		
" "	1	06	....	11	28.10	......	28.02	....	01	W.	S.W.	0	3	3	0	N.	N.	10 S.	Snowing lightly all day.
" "	2	14	22	24	28.04	27.95	27.76	24	09	0	S.W.	S.W.	0	5	5	Fog.	10 S.	10 S.	Mild and overcast, gale S.W.
" "	3	26	31	29	27.65	27.60	27.84	....	24	S.W.	S.W.	S.W.	3	3	1	10 S.	N.	N.	Light snow night and day. ½ in.
" "	4	26	....	05	27.70	.....	28.03	....	26	S.W.	W.	W.	3	4	1	N.	10 S.	9 S.	Light snow and rain.
Cross Lake	5	19	01	11	28.18	28.21	28.32	....	19	0	0	0	0	0	0	0	0	0	
"	6	03	11	15	28.26	28.23	28.20	....	15	N.E.	E.	0	1	2	0	N.	10 S.	10 S.	Light snow betw'n 7 and 8 a.m.
"	7	21	21	23	27.66	27.46	27.38	....	13	N.E.	E.	E.	5	5	2	N.	N.	N.	5 inches snow with gale from E.
"	8	17	20	16	27.56	27.63	27.71	....	15	0	W.	0	0	1	0	10 S.	10 S.	10 S.	
Height of Land	9	09	....	01	27.80	27.93	......	....	09	W.	W.	W.	1	3	1	10 S.	10 S.	....	Light flurries of snow.
Lake Tamiscamie	10	06	....	25	27.99	......	28.48	....	....	0	W.	0	0	1	0	0	0	0	Aurora (3) to-night.
Crooked Lake	11	25	....	07	28.43	......	28.42	....	28	0	E.	0	0	2	0	5 K.S.	Haze.	0	Aurora (1).
Tamiscamie River	12	03	....	04	28.60	......	28.86	....	08	N.W.	W.	0	2	3	0	10 S.	5 S.	0	
Lake Mistassini	13	28	....	04	28.88	......	28.76	....	31	0	0	0	0	0	0	0	0	10 S.	
" "	14	05	....	13	28.78	......	28.67	....	04	W.	S.W.	S.W.	1	3	3	10 S.	N.	N.	Light fall of snow.
" "	15	14	....	10	28.54	......	28.05	....	09	N.E.	N.E.	0	3	3	0	10 S.	N.	0	Heavy snow storm during day.
" "	16	05	....	15	28.62	......	28.45	....	05	N.W.	N.W.	0	5	5	0	0	5 K.S.	0	
" "	17	17	....	....	28.53	......	......	....	22	0	0	0	0	0	0	Haze.	Haze.	Haze.	Thermometers abandoned.
" "	18	....	....	....	......	......	......	....	....	0	0	0	0	0	0	0	0	0	Barometer broken by frost.
Lake Mistassini	19	....	....	....	......	......	......	....	....	0	0	0	0	0	0	0	0	0	Coldest night yet.
" "	20	....	....	....	......	......	......	....	....	E.	E.	E.	1	1	1	10 S.	10 S.	10 S.	Colder than yesterday.
" "	21	....	....	....	......	......	......	....	....	E.	E.	E.	1	1	1	10 S.	N.	10 S.	Light snow in afternoon.
" "	22	....	....	....	......	......	......	....	....	E.	E.	S.	3	4	5	10 S.	N.	10 S.	3 in. snow during night and day.
" "	23	....	....	....	......	......	......	....	....	N.W.	N.W.	N.W.	4	4	4	0	0	0	
H. B. Post Lake Mistassini	24	....	....	28	......	......	......	....	....	0	0	0	0	0	0	0	0	0	
" " "	25	....	....	....	......	......	......	....	....	0	0	0	0	0	0	0	0	0	
" " "	26	....	....	....	......	......	......	....	....	W.	W.	W.	1	2	1	0	0	0	
" " "	27	....	....	....	......	......	......	....	....	W.	W.	W.	1	1	1	0	0	N.	Light snow.
" " "	28	....	....	....	......	......	......	....	....	E.	S.E.	S.E.	2	1	1	N.	10 S.	10 S.	Light snow and rain.
" " "	29	....	....	....	......	......	......	....	....	S.W.	S.W.	S.W.	1	1	1	N.	N.	N.	Raining hard all day.
" " "	30	....	....	....	......	......	......	....	....	W.	W.	W.	3	3	3	0	0	0	
" " "	31	....	....	....	......	......	......	....	....	W.	W.	......	2	3	...	0	3	0	

LOCALITY.	Date.	Thermometer.			Barometer.			Maximum.	Minimum.	Wind.						Weather.			Remarks.
										Direction.			Force.						
	Jan.	7	2	9	7*	2	9			7	2	9	7	2	9	7	2	9	
H. B. Post Lake Mistassini..	1	...	...	...	...	...	...	...	...	...	W.	...	..	3	...	...	0	...	
" " " ..	2	...	...	...	...	...	...	...	...	E.	E.	E.	3	3	3	N.	N.	N.	6 inches of snow.
" " " ..	3	...	...	...	...	...	...	...	...	E.	E.	K.	2	4	3	N.	N.	N.	Light snow flurries.
" " " .	4	...	...	...	...	...	...	...	...	E.	S.	E.	1	1	3	0	5 K.S	N.	Snow falling in evening.
" " " ..	5	...	...	...	...	...	...	...	...	S.	E.	E.	8	8	3	N.	N.	N.	Snowing lightly all day.
" " " ..	6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
" " " ..	7	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
" " " ..	8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
" " " ..	9	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
" " " ..	10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
" " " ..	11	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
" " " ..	12	...	...	...	...	...	28.07	...	...	E.	W.	N.	3	4	5	0	0	0	
" " " ..	13	34	25	38	*28.38	28.50	28.57	10	34	N.W	N.W.	N.W.	4	4	3	0	0	0	
" " " ..	14	19	04	19	28.50	28.48	28.59	03	39	S.E.	W.	W.	1	3	1	0	N.	0	
" " " ..	15	46	10	09	28.66	28.55	28.50	06	46	0	E.	0	0	1	0	5 S.	10 S.	0	
" " " ..	16	15	13	19	28.52	28.58	28.58	06	16	0	W.	0	0	1	0	Haze.	Haze.	Haze.	
" " " ..	17	03	00	03	28.03	27.64	27.68	01	27	E.	E.	N.	3	4	5	N.	N.	0	1 inch of snow.
" " " ..	18	29	26	41	28.20	28.28	28.37	24	29	N.W.	N.W.	0	4	3	0	0	0	0	
" " " ..	19	53	27	45	28.39	28.38	28.46	27	56	0	0	0	0	0	0	0	0	0	
" " " ..	20	19	06	00	28.37	28.26	28.21	00	52	S.E.	S.E.	E.	3	3	3	10 S.	N.	N.	Commenced snowing at 11 a.m.
" " " ..	21	01	10	27	28.24	28.03	28.18	01	06	E.	N.W.	N.W.	3	4	4	N.	10 S.	0	Stopped " "
" " " ..	22	36	19	37	28.35	28.42	28.47	19	37	0	W.	0	0	8	0	0	0	0	
" " " ..	23	06	09	06	......	28.18	28.22	10	37	S.E.	S.E.	S.E.	5	5	1	N.	N.	0	Snow from 4 a.m. to 5 p.m.
" " " ..	24	06	14	12	28.28	28.00	28.06	15	07	0	E.	E.	0	1	3	0	N.	N.	1 inch of snow.
" " " ..	25	04	02	19	27.95	27.95	28.00	16	....	0	W.	0	0	1	0	0	0	0	
" " " ..	26	25	11	15	27.74	27.60	27.72	05	25	0	N.E.	N.W.	0	1	2	0	N.	N.	Light fall of snow.
" " " ..	27	39	31	45	28.00	28.27	28.44	03	40	N.W.	N.W.	0	1	2	0	0	0	0	
" " " ..	28	56	23	40	28.46	28.88	28.25	26	56	0	0	E.	0	0	1	0	0	0	
" " " ..	29	36	03	16	28.19	28.20	28.28	26		0	W.	0	0	3	0	0	N.	0	Snow flurries.
" " " ..	30	13	02	18	28.34	28.36	28.39	03	21	E.	E.	0	1	1	0	0	0	0	
" " " .	31	26	07	82	28.39	28.48	.....	03	29	S.W.	W.	0	1	1	0	0	0	0	
	Feb.																		
" " " ..	1	22	14	18	28.40	28.80	28.30	06	88	W.	N.	N.W.	1	1	3	N.	10 S.	10 S.	Light snow flurries.
" " " ..	2	31	18	26	28.30	28.25	28.25	14	31	N.W.	N.W.	N.W.	1	1	1	0	0	0	
" " " ..	3	35	13	26	28.25	28.15	28.19	18	41	0	N.W.	N.W.	1	1	1	0	0	0	
" " " ..	4	31	02	07	28.10	28.10	27.89	11	36	0	0	0	0	0	0	0	0	0	
" " " ..	5	05	04	10	27.85	28.00	28.15	02	....	0	N.	N.	0	1	1	N.	N.	0	1 inch of snow.
" " " .	6	13	10	39	28.75	28.95	28.37	05	18	N.W.	N.W.	0	1	1	0	0	0	0	

H. B. Post Lake Mistassini..	7	46	05	31	28.49	28.50	28.42	08	46	0	0	N.	0	0	1	0	0	0	
" " " ..	8	19	05	05	28.35	28.32	28.42	02	40	N.W.	N.	0	0	1	0	0	N.	0	Light fall of snow in p.m.
" " " ..	9	10	01	03	28.25	28.65	28.30	07	19	0	N,	N.	0	1	1	10 S.	0	0	
" " " ..	10	25	26	04	27.65	27.59	27.55	26	10	E.	E.	W.	5	5	3	N.	N.	N.	Snow all day, (6 inches.)
" " " ..	11	17	12	14	27.60	27.75	28.00	12	17	S.W.	W.	W.	3	4	3	0	0	0	
" " " ..	12	20	04	35	28.00	28.10	28.20	04	20	S.W.	S.W.	0	4	5	0	0	0	0	
" " " ..	13	42	04	25	28.29	28.39	28.30	04	42	0	S.	0	0	1	0	0	0	0	
" " " ..	14	15	06	10	28.45	28.49	28.45	06	25	E.	E.	0	2	3	0	0	0	0	
" " " ..	15	00	13	08	28.50	28.50	28.50	18	10	S.	E.	E.	3	3	3	10 S.	0	0	
" " " ..	16	10	21	20	28.50	28.35	28.29	32	10	E.	E.	E.	3	4	5	0	0	0	
" " " ..	17	15	21	12	28.10	28.00	28.00	35	15	E.	E.	E.	5	5	1	0	0	0	
" " " ..	18	00	21	13	28.22	28.20	28.20	21	00	E.	0	0	1	0	0	N.	N.	N.	S'w from 7 a.m. to 6 p.m. (6 in.)
" " " ..	19	09	15	10	28.20	28.10	28.10	33	09	0	N.	N.	1	2	3	10 S.	10 S.	10 S.	
" " " ..	20	13	23	19	28.10	28.10	28.15	34	09	W.	N.	N.	1	3	3	10 S.	N.	N.	3 inches of snow.
" " " ..	21	07	20	01	28.29	28.30	28.39	37	07	N.	N.	N.	1	2	2	10 S.	0	0	
" " " ..	22	06	08	03	28.40	28.40	28.45	09	06	N.	N.	N.	1	3	2	0	0	0	
" " " ..	23	15	....	....	28.55	......	......	10	15	N.	......	......	1	0	0	0	0	0	
" " " ..	24	....	....	....	......	......	......	....	....	0	......	......	0	...	...	......	......	......	
" " " ..	25	....	....	....	......	......	......	....	....	......	......	......	...	...	...	......	......	......	
" " " ..	26	10	25	25	28.30	28.20	28.20	25	10	E.	S.	S.	3	2	1	0	N.	N.	1 inch of snow.
" " " ..	27	22	28	20	28.25	28.20	28.25	32	22	0	0	0	0	0	0	N.	N.	N.	Light flurries of snow.
" " " ..	28	08	19	07	28.35	28.35	28.30	30	08	N.	0	0	1	0	0	N.	0	0	1 inch of snow.
	Mar.																		
" " " ..	1	24	30	22	28.10	28.00	28.00	....	....	E.	E.	E.	1	1	1	N.	N.	N.	Com'ced snowing 6 a.m. (1 in.)
" " " ..	2	15	18	08	28.00	27.95	28.00	....	....	N.	N.W.	N.	1	3	3	N.	N.	0	Stopped snowing 7 p.m. (2 in.)
" " " ..	3	17	17	06	28.15	28.20	28.22	....	....	E.	E.	E.	1	1	1	0	0	0	
" " " ..	4	03	26	15	28.20	28.25	28.23	....	....	E.	E.	0	1	1	0	0	10 S.	0	
" " " ..	5	02	....	09	28.32	......	28.50	....	....	N.	......	N.	1	...	3	N.	......	0	
" " " ..	6	24	04	20	28.48	28.49	28.50	....	....	0	N.E.	N.	0	1	1	0	0	0	
" " " ..	7	35	02	22	28.49	28.50	28.50	....	....	0	N.E.	0	0	2	0	0	0	0	
" " " ..	8	27	06	23	28.49	28.49	28.35	....	....	0	N.	E.	0	2	1	0	0	0	
" " " ..	9	31	10	05	28.30	27.95	27.90	....	....	E.	E.	E.	1	3	3	0	0	N.	Commenced snowing at 4 p.m.
" " " ..	10	12	08	15	28.00	28.20	28.35	....	....	0	N.W.	N.W.	0	3	3	0	N.	0	
" " " ..	11	30	11	31	28.40	28.45	28.32	....	....	0	0	E.	0	0	3	0	0	N.	
" " " ..	12	31	03	05	28.55	24.60	28.63	....	....	N.	N.W.	0	3	3	0	0	0	0	
" " " ..	13	08	16	12	28.62	28.50	28.40	....	....	E.	E.	E.	1	3	1	0	0	0	
" " " ..	14	10	18	....	28.30	28.30	......	....	....	0	0	0	0	0	0	0	0	0	
" " " ..	15	01	06	10	28.00	27.80	......	....	....	E.	E.	......	1	1	...	N.	N.	N.	Commenced snowing last night.
" " " ..	16	22	04	11	28.00	28.00	28.15	....	....	W.	W.	W.	1	2	3	0	0	....	Stopped " " (2 in.)
" " " ..	17	22	04	10	28.22	28.22	28.28	....	....	W.	S.W.	0	1	3	0	0	0	0	
" " " ..	18	19	09	15	28.30	28.30	28.32	....	....	0	S.	......	0	1	...	0	0	0	
" " " ..	19	25	11	....	28.29	28.20	......	....	....	0	N.	......	0	1	...	0	10 S	....	
" " " ..	20	01	07	....	27.72	27.75	......	....	....	N.	N.	......	3	3	...	N.	N.	....	Commenced snowing last night.
" " " ..	21	11	03	10	27.90	28.00	28.20	....	....	N.	N.	N.W.	3	2	3	0	0	0	Stop'd snowi'g last night, (2 in.)
" " " ..	22	18	07	18	28.38	28.39	28.42	....	....	N.W.	N.W.	E.	3	2	1	0	0	0	
" " " ..	23	22	18	05	28.45	28.39	28.29	....	....	E.	S.	E.	1	1	1	0	0	0	
" " " ..	24	12	22	02	28.20	28.20	28.25	....	....	E.	S.	N.	1	1	1	0	N.	0	Light snow in middle of day.

* The readings following are taken with an Aneroid Barometer.

LOCALITY.	Date.	Thermometer.			Barometer.			Maximum.	Minimum.	Wind. Direction.			Wind. Force.			Weather.			Remarks.
	Mar.	7	2	9	7	2	9			7	2	9	7	2	9	7	2	9	
H. B. Post Lake Mistassini..	25	21	12	09	28.32	28.32	28.80	....	....	E.	W.	0	1	3	0	0	0	0	
" " " ..	26	04	21	05	28.22	28.25	28.30	....	....	S.	W.	0	1	1	0	0	0	0	
" " " ..	27	10	33	15	28.20	28.00	28.15	....	....	S.E.	W.	W.	1	3	8	0	10 S.	0	
" " " ..	28	03	08	23	28.28	28.35	28.46	....	....	N.	N.W.	0	3	2	0	0	0	0	
" " " ..	29	20	12	10	28.50	28.50	28.50	....	....	0	E.	0	2	1	0	0	0	0	
" " " ..	30	03	27	19	28.49	28.42	28.40	....	....	E.	E.	E.	3	3	1	0	0	0	
" " " ..	31	25	....	27	28.25	......	28.20	....	....	E.	......	0	1	...	0	N.	....	10 S,	Snow 3 inches.
	April.																		
" " " ..	1	30	13	....	28.10	28.30	......	....	....	W.	N.	.....	5	5	...	N.	0	....	Snow.
" " " ..	2	04	21	01	23.59	28.59	28.50	....	....	W.	S.	0	1	2	0	0	0	0	
" " " ..	3	09	22	....	28.60	28.60	......	....	....	0	N.	.....	0	1	...	0	0	....	
" " " ..	4	09	32	20	28.40	28.40	28.20	....	....	0	E.	E.	0	1	1	0	0	0	
" " " ..	5	22	31	22	27.80	27.80	27.80	....	....	W.	E.	0	1	2	0	0	0	0	
" " " ..	6	21	36	21	28.28	28.28	28.45	....	....	N.	N.	N.	1	3	1	0	0	0	
" " " ..	7	24	39	....	28.50	......	......	....	....	E.	E.	.....	1	3	...	10 S.	0	....	
" " " ..	8	36	....	09	28.00	......	28.12	..	...	S.	......	W.	1	...	5	N.	....	N.	Rain and snow.
" " " ..	9	04	19	06	28.22	28.32	28.32	....	..	N.	N.	N.	3	3	2	0	0	0	
" " " ..	10	23	30	25	28.26	28.22	28.22	....	....	E.	W.	0	2	1	0	0	0	0	
" " " ..	11	....	....	....	......	......	......	....	....	.....	.....	.....	...	...	...	......	....	....	
" " " ..	12	....	....	....	......	......	......	....	....	.....	.....	.....	...	...	...	......	....	....	
" " " ..	13	07	25	15	28.39	28.40	22.41	..	....	N.	N.	N.	3	3	1	0	0	.0	
" " " ..	14	08	31	....	28.50	28.50	......	....	....	N.	N.	.....	1	2	...	0	0	....	
" " " ..	15	16	30	....	28.42	28.40	......	....	....	N.	N.	.....	2	3	...	0	0	....	
" " " ..	16	24	30	28	28.40	28.40	28.40	....	....	N	N.	N.	3	3	1	10 S.	0	0	
" " " ..	17	25	38	28	28.62	28.65	28.80	....	....	N.	N.	N.	8	2	1	0	0	0	
" " " ..	18	19	42	25	28.76	28.78	28.71	....	....	0	N.	N.	0	1	1	0	0	0	
" " " ..	19	35	51	35	28.75	28.70	28.62	....	....	0	N.	E.	0	1	1	0	0	....	
" " " ..	20	45	41	37	28.60	28.55	28.60	....	....	E.	W.	N.	1	1	1	0	N.	0	Rain.
" " " ..	21	22	39	35	28.62	28.62	28.62	....	....	N.	N.	0	1	1	0	0	0	10 S.	
" " " ..	22	36	47	47	28.50	28.48	28.38	....	....	E.	S.	E.	1	2	3	N.	0	0	Rain.
" " " ..	23	45	60	45	28.28	29.32	28.35	....	....	E.	S.	S.	1	3	1	0	0	N.	Rain.
" " " ..	24	35	37	16	28.40	28.45	28.45	....	....	N.	N.	N.	1	1	1	0	0	....	
" " " ..	25	18	32	23	28.62	28.62	28.63	....	....	N.	N.	N.	1	3	1	0	0	0	
" " " ..	26	28	40	33	28.50	28.50	28.40	....	...	E.	E.	E.	1	2	1	0	0	0	
" " " ..	27	34	35	24	28.30	28.28	28.30	....	....	N.	N.	W.	1	1	3	N.	N.	N.	Snow.
" " " ..	28	22	36	26	28.38	28.30	28.32	....	....	N.	N.	N.	3	1	1	N.	10 S.	0	Snow.
" " " ..	29	28	....	....	......	......	......	....	....	E.	......	......	1	...	...	0	....	....	
" " " ..	30	31	....	....	28.12	......	......	....	....	N.W.	......	......	1	...	...	10 S	....	....	

	May.																		
H. B. Post Lake Mistassini..	1	20	25	18	28.31	28.31	28.39	30	16	N.	N.	N.	3	1	1	N.	0	0	Snow in morning.
" " " ..	2	16	24	....	28.40	28.40	......	40	11	N.	N.	......	1	2	...	0	0	....	
" " " ..	3	19	29	25	28.28	28.24	28.24	30	08	N.	N.W.	0	3	3	0	0	0	0	
" " " ..	4	40	48	31	28.25	28.25	28.34	48	12	S.	S.E.	N.	1	3	1	0	0	0	
" " " ..	5	36	47	....	28.42	28.44	......	49	15	0	E.	......	0	1	...	0	0	....	
" " " ..	6	38	48	40	28.40	28.40	28.40	51	23	E.	E.	S.	3	3	1	10 S.	10 S.	10 S.	
" " " ..	7	38	48	....	28.38	28.30	......	51	27	E.	E.	......	3	3	...	10 S.	0	....	
" " " ..	8	37	47	....	28.30	28.28	......	51	35	E.	S.	......	1	2	...	10 S.	N.	....	Rain.
" " " ..	9	36	45	33	28.20	28.16	28.16	51	33	W.	0	N.	1	0	1	10 S.	0	0	
" " " ..	10	41	45	35	28.09	28.04	28.04	47	29	N.	W.	N.	2	2	1	0	N.	0	Rain.
" " " ..	11	33	39	....	28.20	28.29	......	36	28	W.	W.	......	3	3	...	0	10 S.	....	
" " " ..	12	....	....	....	......	......	......	42	23	E.	......	......	3	...	...	0	....	....	
" " " ..	13	43	....	....	28.44	......	......	47	37	0	......	......	0	...	...	0	....	....	
" " " ..	14	51	60	....	28.40	28.38	......	56	36	W.	W.	......	3	3	...	0	5 K.S.	....	
" " " ..	15	....	40	....	28.54	......	......	61	28	N.	N.	......	3	2	...	0	....	....	
" " " ..	16	....	66	....	......	28.27	......	....	29	S.W.	S.W.	S.W.	3	3	1	10 S.	10 S.	10 S.	
" " " ..	17	55	47	....	28.24	28.28	......	69	41	N.	N.	......	3	2	...	10 S.	10 S.	....	Showers during day.
" " " ..	18	30	....	....	28.48	......	......	55	31	N.	......	......	1	...	...	10 S.	....	....	
" " " ..	19	34	....	....	28.46	......	......	57	28	N.	......	......	3	...	...	0	....	....	
" " " ..	20	....	....	....	28.60	......	......	55	23	N.W.	......	......	1	...	...	....	....	....	
" " " ..	21	55	....	....	28.61	......	......	67	27	E.	......	......	1	...	...	0	....	....	
" " " ..	22	41	....	....	28.50	......	......	52	35	S.	S.W.	S.W.	1	1	1	10 S.	Haze.	....	
" " " ..	23	40	....	....	28.45	......	......	73	31	S.W.	......	......	1	...	...	0	....	....	
" " " ..	24	73	....	....	28.38	......	......	80	37	W.	......	......	3	...	...	0	....	....	
" " " ..	25	45	....	....	28.26	......	......	85	44	S.	......	......	3	...	...	N.	....	....	Rain showers during day.
" " " ..	26	44	51	....	28.20	28.30	......	75	43	W.	W.	......	3	4	...	10 S.	10 S.	....	Rain showers during day.
" " " ..	27	....	40	....	......	28.55	......	....	....	W.	W.	......	3	3	...	10 S.	10 S.	....	
" " " ..	28	....	....	54	......	......	28.50	...	29	N.W.	N.W.	0	3	3	...	0	0	0	
" " " ..	29	53	67	50	28.46	28.43	28.41	61	30	N.W.	N.	......	1	3	...	0	5 K.S.	0	
" " " ..	30	51	73	63	28.37	28.33	28.30	61	34	......	S.E.	S.E.	...	1	8	0	5 K.S.	5 K.S.	
" " " ..	31	59	67	50	28.31	28.22	28.25	75	46	S.E.	S.E.	S.E.	1	4	4	Haze.	Haze.	10 S.	Began to rain at 5.30 p.m.
	June.																		
" " " ..	1	45	46	46	28.10	28.10	28.21	68	44	E.	E.	E.	3	4	3	10 S.	10 S.	10 S.	Rained all day.
" " " ..	2	40	52	48	28.31	28.39	28.40	50	38	E.	E.	0	1	2	0	10 S.	10 S.	10 S.	Showers during day.
" " " ..	3	46	60	60	28.31	28.25	28.31	58	38	S.E.	W.	N.W.	3	4	3	10 S.	7 K.S.	10 S.	Showers during morning.
" " " ..	4	35	50	40	28.38	28.37	28.39	61	35	N.W.	N.	N.	3	2	1	10 S.	5 K.S.	Clear.	Light flurry of snow at 4.30 a.m
" " " ..	5	38	50	43	28.42	28.37	28.39	56	30	0	N.	0	0	1	0	10 S.	7 K.S.	3 K.S.	Light showers all day.
" " " ..	6	49	....	52	28.40	......	28.34	50	32	0	......	E.	0	...	1	0	3 K.S.	9 S.	Heavy rain in a.m. with snow.
" " " ..	7	50	48	40	28.13	27.09	28.05	70	40	S.E.	S.E.	N.W.	5	5	4	10 S.	10 S.	10 S.	Flurries snow during day ½ in.
" " " ..	8	35	45	35	27.98	27.87	27.91	52	35	S.	S.E.	N.W.	3	4	3	10 S.	10 S.	10 S.	
" " " ..	9	35	46	40	28.14	28.24	28.30	51	32	N.W.	N.W.	W.	3	3	3	10 S.	10 S.	5 K.S.	
" " " ..	10	45	57	52	28.46	28.47	28.48	46	32	N.W.	N.W.	0	1	1	0	0	5 K.S.	2 K.S.	Light showers during the night
" " " ..	11	55	68	58	28.48	28.50	28.49	61	32	0	S.W.	0	0	1	0	5 K.S.	0	0	
" " " ..	12	53	62	54	28.41	28.37	28.30	70	39	S.	S.	S.	2	5	3	5 K.S.	10 S.	10 S.	Rain at 2 p.m.
" " " ..	13	58	68	57	28.08	28.18	28.18	70	52	W.	W.	0	1	2	0	10 S.	3 S.	5 S.	Stopped raining at 11 a.m.
" " " ..	14	45	65	60	28.15	28.23	28.32	75	45	N.	N.W.	0	1	1	0	10 S.	5 S.	0	Rain from 12.30 a.m. to 8 a.m.
" " " ..	15	57	71	62	28.40	28.37	28.20	67	37	E.	S.	S.	1	1	1	0	8 S.	5 S.	
" " " ..	16	65	60	42	28.10	28.16	28.25	76	55	S.W.	W.	N.W.	1	4	4	10 S.	8 S.	8 S.	Light showers during night.

LOCALITY.	Date	Thermometer.			Barometer.			Maximum.	Minimum.	Wind. Direction.			Wind. Force.			Weather.			Remarks.
	June.	7	2	9	7	2	9			7	2	9	7	2	9	7	2	9	
H. B. Post Lake Mistassini..	17	40	65	....	28.30	28.27	.....	71	38	S. W.	S.W.	......	1	4	...	10 S.	8 S.	....	Light rain during afternoon.
" " " ..	18	....	58	40	......	28.39	28.49	68	39	......	W.	N. E.	...	1	1	....	10 S.	5 S.	" " night.
" " " ..	19	46	65	53	28.50	28.48	28.50	60	30	S.E.	N.W.	0	1	1	0	0	5 S.	0	Aurora (2) last night.
" " " ..	20	50	67	55	28.50	28.41	28.40	72	40	S.E.	S.	S.	1	1	1	0	8 S.	10 S.	Rain from 5 p.m. to 10 p.m.
" " " ..	21	57	72	65	28.30	28.20	28.11	70	48	S.	S.	S.	2	4	1	0	Haze.	10 S.	Rain 3 p.m.
" " " ..	22	45	45	44	28.08	27.99	28.12	77	43	W.	N.W.	S.W.	3	2	3	10 S.	10 S.	5 S.	Rain all day.
" " " ..	23	40	44	38	28.00	28.00	28.14	50	36	W.	N.W.	N.W.	4	4	1	10 S.	10 S.	10 S.	Light sho'ers rain & sno' all d'y
" " " ..	24	46	71	59	28.25	28.22	28.31	48	35	S.	W.	W.	1	3	1	10 S.	5 K.S.	5 K.S.	Showers during night and day.
" " " ..	25	65	73	65	28.31	28.31	28.31	74	47	W.	W.	0	1	3	0	0	8 K.S.	0	Thunder shower in p.m.
" " " ..	26	65	75	62	28.44	28.45	28.41	79	52	0	N.W.	0	0	1	0	0	5 K.S.	0	" " a.m.
" " " ..	27	60	70	62	28.37	28.33	28.35	78	52	S.	W.	N. W.	2	3	1	8 K.S.	5 K.S.	8 K.S.	Heavy thunder showers.
" " " ..	28	43	52	47	28.51	28.45	28.49	77	38	N.	W.	N.	1	1	1	5 K.S.	5 K.S.	8 K.S.	
" " " ..	29	46	....	....	28.41	......	......	53	38	N.	......	......	1	...	...	5 K.S.	....	....	
" " " ..	30	....	....	....	......	......	......	....	....	......	......	......	...	...	...	....	....	....	
	July.																		
" " " ..	1	49	57	55	......	......	......	53	40	N.E.	N.E.	N. E.	1	1	1	10 S.	N.	N.	
" " " ..	2	56	66	62	......	......	......	68	49	N.E.	N.W.	E.	1	2	1	5 K.S.	9 K.	5 K.	
" " " ..	3	60	74	60	......	......	......	73	51	E.	N.E.	E.	1	2	1	7 K.S.	5 K.S.	5 K.	
" " " ..	4	60	76	59	......	......	......	76	53	E.	S.E.	S.E.	1	2	1	10 S.	5 K.S.	5 K.S.	
" " " ..	5	66	78	64	......	......	......	76	51	S.E.	S.	S.	1	4	1	0	10 S.	5 K.	
" " " ..	6	63	77	68	......	......	......	74	58	S.E.	S.	S.	1	2	1	10 S.	0	0	
" " " ..	7	60	70	66	......	......	......	78	61	S.E.	S.E.	S.	3	5	1	0	N.	7 K.S.	
" " " ..	8	68	...	63	......	......	......	74	62	S.	......	S.	3	3	4	9	....	7 S.	
" " " ..	9	64	69	58	....	......	......	72	58	S.W.	W.	N.W.	3	4	3	5 K.	5 K.	7 K.S.	
" " " ..	10	42	54	48	......	......	......	72	41	N.W.	N.W.	N.	4	2	1	10 S.	9 K.	0	
" " " ..	11	52	70	56	......	......	......	61	39	S.W.	W.	N.	1	4	1	7 S.	5 K.S.	0	
" " " ..	12	61	74	64	......	......	......	71	44	S.W.	S.W.	S.	1	3	1	0	7 K.S.	0	
" " " ..	13	65	79	64	......	......	......	....	60	S.W.	S.	S.	3	4	3	5 K.	7 S.	0	
" " " ..	14	46	52	51	......	......	......	....	46	N.	N.	N.W.	3	2	1	N.	N.	N.	
" " " ..	15	50	66	57	......	......	......	54	49	N.W.	N.W.	W.	2	3	1	10 S.	5 K.	7 K.S.	
" " " ..	16	57	74	66	......	......	......	66	48	S.W.	S.W.	S.W.	1	3	1	7 K.S.	8 K.S.	10 S.	
" " " ..	17	66	72	49	......	......	......	75	59	S.	W.	N.W.	3	5	3	N.	7 S.	10 S.	
" " " ..	18	45	60	53	......	......	......	72	39	N.W.	N.W.	N.W.	3	2	1	7 S.	7 S.	0	
" " " ..	19	56	58	55	......	......	......	69	46	S.W.	S.	N.W.	1	1	1	N.	N.	10 S.	
" " " ..	20	58	76	55	......	......	......	57	45	N.	E.	E.	1	1	1	10 S.	5 K.	5 K.	
" " " ..	21	59	76	57	......	......	......	....	51	E.	N.W.	W.	1	1	1	5 K.	7 S.	7 K.S.	
" " " ..	22	51	62	50	......	......	......	....	50	N.	N.W.	N.	3	2	1	10 S.	8 K S.	0	
" " " ..	23	63	....	....	......	......	......	70	46	S.	......	......	1	...	...	0	....	....	

H. B. Post Lake Mistassini..	24							76										
" " " ..	25																	
" " " ..	26																	
" " " ..	27																	
" " " ..	28																	
" " " ..	29																	
" " " .	30																	
" " " .	31																	
	Aug.																	
" " " ..	1	48	60	53	28.49	28.50	28.50	61	41	0	N. W.	0	0	1	0	8 K.S.	10 S.	0	Rain from 7.30 a.m. to 4 p.m.
" " " ..	2	51	68	54	28.66	28.60	28.65	65	31	0	S.	0	0	1	0	0	0	0	
" " " ..	3	54	72	65	28.50	28.43	28.41	75	43	S.E.	S.E.	S.E.	1	5	3	0	0	5 K.S.	Aurora (2).
" " " ..	4	54	61	62	28.20	28.02	28.06	74	52	S.E.	S.E.	S.E.	5	5	3	10 S.	10 S.	10 S.	Began to rain at 2 a.m.
" " " ..	5	46	45	44	28.21	28.40	28.52	74	46	W.	N.W.	N.W.	3	2	1	10 S.	10 S.	8 K.S.	Ceased raining at 4 p.m.
" " " ..	6	47	65	50	28.64	28.61	28.66	50	33	0	N.E.	0	0	1	0	0	5 K.S.	0	Frost on low ground.
" " " ..	7	51	65	50	28.65	28.65	28.59	65	38	0	S.E.	0	0	3	0	0	0	0	Aurora (3).
" " " ..	8	55	75	63	28.55	28.64	28.58	72	45	0	S.	S.	0	3	1	0	0	0	Aurora (3). Began rain 6 p.m.
" " " ..	9	60	71	62	28.56	28.46	28.42	75	52	S.	S.	S.	3	3	1	3 K.S.	7 K.S.	10 S.	Showers during a.m.
" " " ..	10	53	65	62	28.46	28.51	28.52	73	53	N.W.	N.	0	1	1	0	10 S.	3 K.S.	0	
" " " ..	11	58	....	61	28.52	.....	28.49	68	52	0	......	0	0	...	0	0	....	5 K.S.	Aurora (3). Showers till 3 p.m
" " " ..	12	62	68	62	28.50	28.44	28.41	81	52	0	0	0	0	0	0	10 S.	10 S.	3 K.S.	
" " " ..	13	61	74	65	28.31	28.21	28.14	73	53	S.	S.	S.	3	3	1	0	7 K.S.	10 S.	Began to rain at 5 p.m.
" " " ..	14	55	44	46	28.04	28.12	28.19	72	53	N.W.	N.W.	N.W.	3	4	1	10 S.	10 S.	8 K.S.	Stopped raining at 4.30 p.m.
" " " ..	15	48	59	52	28.29	28.37	28.41	58	42	0	S.W.	0	0	3	0	8 K.S.	5 K.S.	8 K.S.	Showers during the night.
" " " ..	16	51	71	62	28.54	28.51	28.46	63	41	S.W.	S.W.	S.W.	1	2	1	7 K.S.	5 K.S.	10 S.	" " "
" " " ..	17	56	72	60	28.52	28.39	28.39	72	50	S.W.	S.W.	S.W.	1	4	1	8 K.S.	5 K.S.	7 K.S.	Rain 3 a.m. to 11 a.m.
" " " ..	18	56	74	60	28.31	28.21	28.18	74	56	S.W.	S.W.	S.W.	1	1	1	10 S.	8 K.S.	7 K.S.	Showers during night and day.
" " " ..	19	51	49	42	28.16	28.19	28.31	74	51	W.	N.W.	0	3	3	0	8 K.S.	10 S.	0	" " "
" " " ..	20	50	55	48	28.36	28.41	28.44	52	39	W.	W.	0	3	3	0	0	10 S.	0	" " "
" " " ..	21	52	55	....	28.50	28.46	......	60	37	S.E.	S.	.....	3	4	...	5 K.S.	10 S.	....	Rain showers during day.
" " " ..	22																		
" " " ..	23																		
" " " ..	24																		
" " " ..	25																		
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GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA
ALFRED R. C. SELWYN, LL.D., F.R.S., F.G.S., DIRECTOR.

OBSERVATIONS

ON THE

GEOLOGY, ZOOLOGY AND BOTANY

OF

HUDSON'S STRAIT AND BAY,

MADE IN 1885.

BY

ROBERT BELL, B.A.Sc., M.D., LL.D., F.R.S.C.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

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1885.

OTTAWA, April, 1886.

TO ALFRED R. C. SELWYN, ESQ., LL.D., F.R.S., F.G.S.,

Director of the Geological and Natural History Survey of Canada.

SIR,—I beg to submit, herewith, my report as Geologist and Naturalist on the Second Expedition to Hudson Strait and Bay, sent out by the Government of Canada on board the steamship "Alert" in 1885.

I have the honour to be,

Sir,

Your obedient servant,

ROBERT BELL.

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HUDSON'S STRAIT AND BAY,

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ROBERT BELL, B.A.Sc., M.D., LL.D., F.R.S.C.

My preliminary report, of December, 1885, gave a general account of the field-work of the year, and a narrative of the Second Hudson's Bay Expedition by the steamship "Alert," as far as the geological and biological work are concerned. I purpose, therefore, in the following pages, to confine my remarks to a fuller description of the results in these departments. These were, unfortunately, very limited, owing to the fact that most of our time was spent either at sea or in the ice, or in relieving the stations, which I had already visited on the "Neptune" expedition of the previous year, and had done as much geological work as possible in their neighborhoods. A month in the middle of summer, was also consumed in our voyage from the Straits to St. John's, Newfoundland, and back again, after the "Alert" had there undergone some necessary repairs.

Botanical specimens were again collected at all places visited. Collections of plants had also been made by some of the observers at the stations before the arrival of the "Alert." Although the number of speciments obtained is quite largo, yet only five species can be added to the list of 1884. In the appendix to the present report will be found a catalogue, by Prof. Macoun, of the plants collected while we were in Newfoundland. I am indebted to Major H. H. Lyman, of Montreal, for having prepared the accompanying list of the Lepidoptera, and some other insects collected last year by myself and Messrs. H. M. Burwell and Arthur Laperrière. The Coleoptera

Botanical collections.

Entomological collections.

have been kindly examined by Mr. W. H. Harrington. A number of specimens of birds, mammals and fishes were collected during the voyage, or obtained from some of the observers, especially Mr. Laperrière, who was in charge of the station at Cape Digges. I am indebted to Dr. Mathews, of York Factory, for additional specimens of birds, and to Mr. J. R. Spencer, of Churchill, for specimens of Back's grayling, and other fishes. After the zoological specimens shall have been critically examined, complete lists of them, along with those obtained around Hudson's Bay in previous years, will be published. I have much pleasure in acknowledging the kindness of the Right Revd. Charles Guay, of Cross Point, P.Q., in procuring canoes and endeavouring to hire Indians for the expedition. Mr. James MacNaughton, M.A., acted as my assistant during the season.

Birds, mammals and fishes.

Report furnished the Department of Marine.

It was considered desirable that the Report of the "Alert" Expedition, to be published by the Department of Marine, should contain an account of the geology of Hudson's Bay and the surrounding country; and accordingly, with the approval of the director, a report on this subject has been furnished. It embraces not only the general results of the geological observations of the "Neptune" and "Alert" expeditions of 1884 and '85, but also of the previous expeditions around Hudson's Bay, made principally on the east side, in 1875 and '77, and on the west side in 1878, '79 and '80, and in the interior in 1870 and '71. A chapter on the Economic Minerals of the Hudson's Bay Territories generally, is also included in the above Report.

As all matters concerning ice, ocean currents, soundings, tides, meteorological phenomena, etc., belong to Lieut. Gordon's province, and will be fully reported on by him, I shall not allude to them except in their relation to geological questions.

Voyage from Halifax to Hudson's Strait

As stated in my preliminary report, we left Halifax on the 27th of May, and after passing through the Gulf of St. Lawrence and the Straits of Belle Isle, steamed northward, near the edge of the ice-pack off the Labrador coast, to the entrance of Hudson's Strait, which we entered on tke 16th June. Beyond the Straits of Belle Isle numerous ice-bergs were passed every day, both in the open water, and among the field ice. When in the latter position they were observed to be almost always more or less completely surrounded by a space of open water. On the voyage back from Newfoundland to the straits, between the 27th of July and the 3rd of August, icebergs were again equally numerous, especially as we approached the Labrador coast, but on neither occasion did we meet with any of remarkable size or height, the great majority of them being comparatively small. Towards the entrance of Hudson's Strait it was noticed that the bergs furthest out to sea or to the eastward, carried stones, mud, or discolorations more fre-

Ice-bergs.

British American Bank Note Co. Montreal.

NORTH SIDE OF ENTRANCE TO NACHVAK INLET, LABRADOR.

SHOWING THE STEEP AND UNGLACIATED CHARACTER OF THE MOUNTAINS.

quently than those near the Labrador Coast. We entered Nachvak Inlet on the 1st of August, and were informed by Mr. Skynner, who had been in charge of the observatory station there since the previous year, that the fixed ice of the inlet had only disappeared on the 12th of July. Local ice. We afterwards learned that it had also cleared from Ashe's Inlet, (near North Bluff) in Hudson's Strait on the same day. Mr. Skynner informed us that the fixed ice extended only as far out as "The Breaker," a rock at the entrance of the inlet. Outside of this the ice was moving with the winds and currents all winter. In the months of June and July, wide lanes of open water were formed between the field-ice and the land. As far as could be observed, this ice was clear or free Foreign matter on field-ice. from dust and rock-debris, as if it had been formed away from the land. The clear ice continued till the end of June, when foreign matter began to appear upon the slowly moving floes. This, Mr. Skynner thought, was due to the fact that about that time the ice began to leave the adjoining shores, after having received upon its surface more or less rocky debris from the crumbling cliffs and slopes, or from having had earthy matter incorporated in it by freezing and by the action of high tides, such as those of Ungava Bay. During the winter, he found that the strong winds carried considerable quantities of dust and angular fragments of rock from the high cliffs and steep and loose taluses on either side of Nachvak Inlet, out upon the fixed ice, and when it broke up in July, this material was borne off to sea. Towards the end of July, all the field ice of the northern parts of the Labrador coast was discolored or "foxy," and had a decayed appearance. The dust or mud, Decaying ice. with which it was covered, was mostly yellowish and greyish in color. Gravel, angular stones, patches of stoney mud, and an angular boulder were occasionally observed.

Reference was made in my report of last year (p. 14 and 37 DD) Non-glaciated mountains of Labrador. to the steep, serrated and non-glaciated appearance of the mountains, along the northern part of the Labrador coast. Opportunities were afforded me in 1884, while passing up and down the coast in the "Neptune," and when ashore at a few points, of studying, sketching and photographing these mountains; and again, last year, their features were well brought out under the varying quantities of snow upon them in the months of June, July, August and October. The accompanying view, from a photograph, looking northward, across the entrance of Nachvak Inlet, is characteristic of the scenery on this part of the coast. As stated in last year's report, glacial grooves are to be seen in this inlet near the sea-level and parallel to the general course of the shores, but no trace of them could be observed on any of the higher levels which were examined. Terraces or banks of gravel and ancient shingle Elevated terraces and beaches. beaches were observed on either side of the inlet at various heights up

to an estimated elevation of 2000 feet. The mountains everywhere in this vicinity give evidence of long-continued atmospheric decay. The annual precipitation at the present time is not great, otherwise small glaciers would probably form among these mountains, which lie between latitudes 58° and 60°, and which overlook a sea, bearing field ice for half the year, and from which bergs are never absent. Patches of snow, however, remain throughout the summer in shaded parts of the slopes and on the highest summits, which range from 4,000 to 6,000 feet above the ocean.

Cape Chudleigh

Our stay at Port Burwell, Cape Chudleigh, on the inward voyage, was for only one night, and while we were in this port, on our return, the weather was so boisterous as to prevent me from going to any considerable distance from the ship. Some additional facts of interest were, however, noted in regard to the glacial phenomena of the neighborhood.

Mica and graphite.

It was stated in my report of last year that when we were at Ashe's Inlet, near North Bluff, the Eskimo gave us specimens of mica and graphite from the north shore of the Strait. During the winter and spring they brought to Mr. Ashe, the gentleman in charge of the observatory station at this place, numerous pieces of these minerals. From what they told Mr. Ashe, he concluded that both kinds were found at different localities all the way from Kimnirook, (see Report for 1884), westward to the place which the natives call Akuliak, at or near which Captain Spicer's trading station is situated. The mica appeared to be quite common. The specimens carried to Mr. Ashe, had apparently all been gathered on the surface; and, as the natives stated that it had been taken away in commercial quantities by the vessels visiting Capt. Spicer's station, the inference is that it must be abundant somewhere not far off. The largest specimens which I saw were about a foot in diameter. All were of a light-brown colour, and transparent when in moderately thin plates. Some pieces which I tested stood the fire well. From the accounts of the Eskimo last year, we inferred that they had found red hematite, inland from Kimnirook, but Mr. Ashe did not receive any specimens of it. In addition to pieces of quartz and iron pyrites they brought him a crystal of black sphene, an inch in diameter, from the north side of the straits opposite the station. The finding of a loose piece of crystalline limestone, like a common variety in the Laurentian rocks further south, was mentioned last year. The occurrence of sphene and graphite constitute, perhaps, additional evidence of the existence of such limestone *in situ* on the north side of Hudson's Strait. While exploring Big (or Turenne) Island, Mr. Ashe had found in its southwestern part a great mass, *in situ*, of a very coarse, greenish-grey hornblende rock, composed of large, radiating crystals,

Quality of mica.

Coarse hornblende rock.

similar to a loose mass which I had noted the previous year not far from the station. This is an additional fact indicating an eastward movement of the ancient glaciers.

Stratification of gneiss.

On the main north shore of the straits, just west of the channel between it and Big Island, the stratification of the gneiss is very conspicuous. The strike is parallel to the above, and the dip is northward for a considerable distance. While drifting up and down with the ice near to the coast in these parts, the peculiarities of the gneiss, and of veins cutting it, could be observed, but there is no chart of the shore or other means of identifying the localities.

Limestone fragments on ice-pans.

Limestone north of Hudson's Strait

Limestone of Melville Peninsula.

Many of the pans of field-ice off Big Island had gravel strewn upon them. This was found to consist of gneiss with a certain proportion of darkly-colored schists. But on ice-pans further up the coast, or to the north-westward, I found fragments of shaly marl and of grey limestone with fossils, among which *Receptaculites Oweni* was easily distinguished. Shells and bryozons, belonging to moderately deep-water species, were found on the same pans. The limestone fragments, just mentioned, would point to the occurrence of Silurian rocks on or near the great bays in the western part of the north-shore of the Straits, where the land is said to be low. Dr. Franz Boas of Berlin has recorded the existence of these rocks in the interior of Baffin Land, only about two degrees of latitude north of this region. He says:* "Through the occurrence of the Silurian rocks on the Nettilling (Lake) the discovery of the same formation at the upper end of Frobisher Bay increases in value. We must now suppose that the Silurian limestones, which appear at Prince Rupert's Inlet, extend from there to Frobisher Bay, and overlie the granites and gneisses of Baffin's Bay and Davis' Strait. We will not be far astray if we connect this extensive Silurian district with the limestones which occur to the south of Igluling, and which form the flat eastern half of Melville Peninsula. Southward from Nettilling, these rocks rise into low hill-ranges, which are indicated on the sketch by Padloaping."

White Bear Sound.

In a letter to me, referring to the geology of Baffin Land, Dr. Boas says: "The most interesting geological problem of the country is a study of the line of division between the Silurian plains and the eastern highlands. I suppose that Silurian rocks will be found, either in the remotest corner of White Bear Sound, or close to it. Probably the strata will be found lying horizontally, and then soundings in the Lakes Amakdjuak and Nettilling, will be of great importance. It must be important for the problems of glaciation to survey the *inner* rim of the

* Page 50 of Dr. A. Petermann's Mitteilungen aus Justus Perthes Geographischer Anstalt, Nr. 80. Gotha, November, 1885.

enormous basin formed by the chain of mountains of Davis' Strait, the plateau of Nugumit, Kinguait, Sikosuilat, Southampton Islands and Melville Peninsula,"

In my report of last year, it was stated that fragments of grey, drab aud yellowish-fossiliferous limestone, apparently Silurian, were common near Cape Chudleigh. If the supposition be correct that the glaciation of Ungava Bay was from the southward out into Hudson's Strait, and thence round Cape Chudleigh into the bed of the ocean, these fragments would indicate that the limestones from which they are derived exist somewhere in the bay, either under the water or on Akpatok Island, which is described as low and level.

Ungava Bay.

Having failed to enter Ashe's Inlet on the inward voyage, we crossed the straits to Stupart's Bay, in Prince of Wales' Sound. Our visit to this station was too brief to allow me to make any fresh geological explorations in the neighborhood. The geology and scenery of this locality are described in my report of last year. The accompanying engraving, from a photograph, represents a view of the country from Eskimo Inlet, about two miles south of Stuparts' Bay, looking westward, and it may be taken as a characteristic specimen of the scenery on the south side of Hudson's Straits. I found that Mr. Stupart and his associates had collected numerous geological specimens for me. They consisted of gneiss, soapstone, quartz, felspar, hornblende, mica-rock, epidote and iron pyrites, all apparently derived from ordinary Laurentian rocks, which prevail everywhere in this region.

Stupart's Bay.

While at Port de Boucherville, on the south end of Nottingham Island, some further exploration was made in the vicinity, but nothing worthy of remark, was observed.

Last year Mansfield Island was found to consist of flat-lying, grey limestones. The fossils then collected, on its eastern side, although badly preserved and not numerous, indicate the age of our Niagara formation.

Niagara formation.

Similar limestones prevail on Southampton Island (proper) from Cape Southampton to within twenty-five or thirty miles of Cape Pembroke at its north-eastern extremity, the latter interval being occupied, according to Captain William Hawes, of the Hudson's Bay Company, by rugged, dark-looking rocks, like those of Hudson's Strait, which are Laurentian gneiss. The large island north of Southampton Island, of which Seahorse Point forms the eastern extremity, and which Lieutenant Gordon has called Bell's Island, in the absence of any other name, is mountainous and appears to consist of gneiss.

Southampton Island.

Gneiss.

In the end of August, while the "Alert" was lying in Port Lapierrière, at Lieut. Gordon's request, and with the assistance of Mr. James Tyrell, P.L.S., I made a track-survey of the Outer Digges Island. It

Track-survey of Outer Digges.

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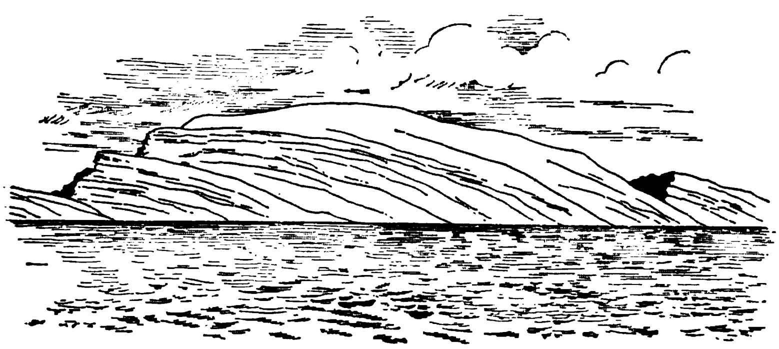
VIEW WESTWARD IN PRINCE OF WALES SOUND, HUDSON'S STRAIT

SHOWING OUTLINE OF MOUNTAINS IN THIS REGION. ESKIMO TENTS IN FOREGROUND

was found to be about eight miles long and three miles wide, and to be separated from the Inner Digges by a straight channel, about one mile wide. It is formed entirely of Laurentian gneiss, which strikes with the longer axis of the island. This island has been thoroughly glaciated. Around its western end the groovings run north-eastward (true), but along the north side they set more nearly east, showing that the stream of ice was flowing out of the bed of Hudson's Bay and eastward in the Strait. The outer points of this shore are all rounded and bald, with the glacial grooving and fluting strongly marked, as may be seen in the accompanying sketch of one of these small capes. Glaciation.



CAPE ON NORTH SIDE OF OUTER DIGGES ISLAND.

The south-eastern part of Inner Digges Island presents a high and nearly vertical cliff, facing the still higher bluffs of Cape Wolstenholme, of which an outline-sketch was given in my report for 1880. From the cape these bluffs continue southward for some miles, diminishing in height and merging into the rounded hills of the coast further down. At about thirty miles south of the cape the country, forming the immediate coast, has become comparatively low, but ranges of partially-rounded hills rise higher and higher towards the interior. On our return from the west side of Hudson's Bay in the month of September, I explored this part of the coast in a small boat, and found the rocks to consist of common forms of gneiss, with veins and patches of fine-grained red granite in some places. On the mainland, about twenty miles south of Port Lapierrière is a very ancient Eskimo camping ground, which is still inhabited. We could not ascertain from the natives what they called the place, and for the sake of convenience in having some name for it we called it Hyla. In this neighborhood the evidences of the rapid recession of the sea are visible on all sides, in the form of shoaling bays and lagoons, as well as in raised beaches and ridges of shingle. The latter sometimes form the isth-

High bluffs of Cape Wolstenholme.

Coast south of Cape Wolstenholme.

Recession of the sea.

muses, separating bays or connecting islands with each other or with the main land. Ponds and small lakes, of a mile or two in length, are numerous between the ranges of hills, or small mountains in the rear. The clay and sand in the valleys between these ridges, up to an elevation of about 200 feet above the sea, are full of marine shells, of which the genera *Tellina, Saxicava, Cardium, Pecten, Mya, Mytilus* and *Astarte* are the most common. Viewed from a distance, these hills and mountains have a naked appearance, but in walking over the country itself, the grasses and sedges, and a variety of Arctic plants which grow around the ponds and lakes, and in sheltered places among the hills, give the landscape a pleasantly green appearance in many places. No shrubs are to be seen except the creeping willows, but the Eskimo make mats for the floors of their summer tents by fastening together, in regular order, twigs of dwarf birch, (*Betula glandulosa*, Michx,)about three feet long, which we understood they obtained in the interior. The natives on this part of the coast live by hunting the reindeer among the hills, and the white whale, polar bear, walrus and seals on the coat. At certain seasons they also procure a good supply of waterfowl and brook trout.

Appearance of the country.

Close to the shore, behind an island, and about a mile south of the old Eskimo camps, above referred to, a very conspicuous vein is exposed along the face of a bluff of gneiss. It is about thirty feet wide in one part, and consists of white quartz next the walls, with coarsely crystalline red felspar in the centre. A few plates of darkly-coloured, uneven mica were also observed.

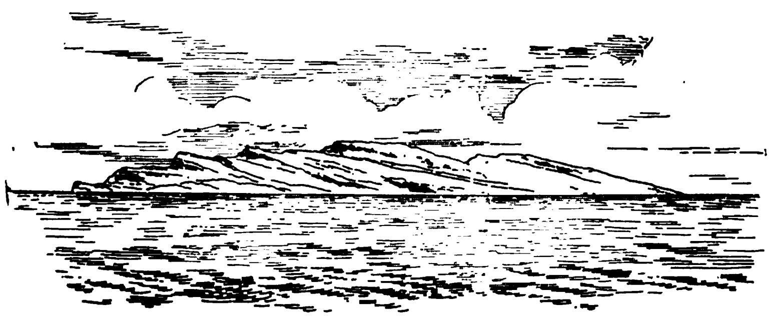
Large quartz and felspar vein.

The general outline of the land on this part of the coast, as seen from a distance out at sea to the westward, slopes gradually up to the westward, until the brink of the great precipices of Cape Wolstenholme are reached. The elevated plateau above the precipices has a tolerably even appearance, as if it had been smoothly and uniformy glaciated. The high and almost perpendicular precipices of Cape Wolstenholme and the east end of the Inner Digges Island, which faces each other, present a singular contrast to the planed surface of the Outer Digges, and the apparently glaciated plateau of the mainland above the cape. It is possible that part of the ancient glacier, in passing out of the bed of Hudson's Bay, became jammed against the inside of the high angular barrier formed by the Digges Islands, on the one hand and the mainland on the other. The narrow channel which separates the Inner Digges from Cape Wolstenholme must be very deep, if we may judge from the quantity of water which flows through it with every tide, producing a strong current in the sea to the south of the Digges Islands.

Elevated plateau.

During our short visit to the harbour of Churchill a strong gale of wind with rain prevailed, so that no fresh geological work could be attempted beyond the limits which had been explored in this vicinity

in 1879. On the return voyage from Churchill, we visited a large chain of islands in the north-eastern part of Hudson's Bay, which run north-eastward between latitudes 59° and 60°, terminating in that direction east of latitude 80°. On some sketch-charts, a group of islands in this part of the bay had been marked "Sleepers," but as there are also two other groups called North Sleepers and South Sleepers, not far off, Lieutenant Gordon and I named these the Ottawa Islands, in order to distinguish them clearly and to prevent confusion. Lieutenant Gordon made a running survey of the northern part of the chain, and we named the individual islands in honor of the citizens of Ottawa who had generously aided in missionary enterprise in Hudson's Bay. A copy of Lieutenant Gordon's chart of the Ottawa Islands accompanies this report. The outermost of these shown on the chart, and called J. Gordon Island, consisted of thick, stratified masses, presenting a variety of external appearances, and probably of volcanic origin, all dipping westward at a moderate angle, as represented in the accompanying outline of the island. The Ottawa Islands.

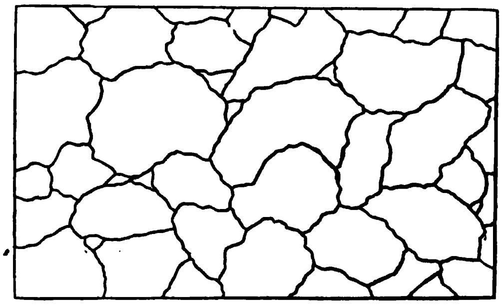


J. GORDON ISLAND FROM THE NORTH.

An opportunity was afforded me of landing upon a small island lying about two miles to the southwest of Gilmour Island (see chart) in latitude 59° 48′, longtitude 80° 6′. It was found to consist entirely of a greenish-grey diorite, which, on fresh fracture, is mottled with darker and lighter shades. In a vertical section, found on the east side of the island, the diorite presents the "bouldery" or concretionary appearance shown in the annexed sketch, the larger divisions having a diameter of about two feet. The rock is cut by small veins of quartz, running in a northwesterly course (true) in which specks of copper pyrites were detected. It also contains thin, short and irregular veins of asbestus and green epidote. Old weathered surfaces of the diorite are very rough, but nearly the whole island bears the marks of glaciation. On the southern and central parts of the island the principal striæ run N. 60° to 80° E., magnetically, or N. 20° to 40° E., astronomically, the Greenish-grey diorite. Copper pyrites and asbestus.

variation of the compass having been found to be about 40° W. Another set of grooves, near the centre of the island, was found to run S. 65° E. mag., or about N. 75° E., true. On the east side of the island the grooves run N. 35° E. mag. or N. 5° W., true.

Glacial striæ.



The forms of the roches moutonné and other evidence afforded by the grooving and fluting of the rocks of this island themselves, go to show that the direction of the glaciating force was from the southward and south-westward and not from the contrary direction. Raised beaches are well marked up to the highest point of the island, about forty or fifty feet above the sea level. Much of the shingle of the island consists of dolomite of the Manitounuck group, and this fact is a further evidence that the drift in this region came from the southward, since these rocks have, as yet, been found only on the islands and shore of the Eastmain coast between Cape Jones and Cape Dufferin. The islands further out to sea, opposite to this part of the coast are also believed to consist of rocks of the Manitounuck group. Specimens, said to have been broken from the fixed rocks of the Belchers, opposite Little Whale River, were obtained at my request, from the Eskimo and are found to consist of amygdaloid, white and grey dolomite, a soft grey schist and columnar calcspar, the last named apparently from a thin vein.

Northward course of drift.

Belcher Islands

Appearance of the Ottawa Islands.

All the larger islands of the Ottawa group are bare, rugged and mountainous. The rocks of Perley, Pattee, Gilmour, Booth and Bronson Islands appeared to be all the same as those of the small island which has been described. The surface of the hills, which on Gilmour Island rise to a height estimated to be about 1,800 feet, is everywhere extremely rough and pitted in appearance.

Walruses and white whales.

We found the small island, on which we landed, inhabited by considerable numbers of walruses. Some white porpoises or small white whales (*Delphinopterus catodon*, Linn.) were also seen in the vicinity. The remains of a number of Eskimo camps and part of the skeleton of a large whale were observed on the island. A few pieces of driftwood had been cast upon it.

The Laurentian System Around Hudson's Bay.

The vast Laurentian area of the north-eastern part of North America forms a very considerable proportion of the whole continent and, geologically speaking, it may be regarded as its nucleus. Greenland, on the other side of Baffins' Bay and Davis' Straits, consists, as far as known, almost altogether of the same rocks. Hudson's Bay, which is nearly half as extensive as the Mediterranean Sea, lies in the middle of the continental portion of the great Laurentian area and the waters drain into it from all sides. The country slopes towards it from the Rocky Mountains, more than 1,300 miles to the westward, from the centre of Labrador, 500 miles to tho eastward and from the immediate vicinity of Lake Superior in the south. Thus, the waters of this great interior sea occupy only the centre of what may be called the basin of Hudson's Bay. This wide depression has existed from early geological times, as is shown by the Manitounuck rocks of the eastern shore and islands and by the Silurian limestones of Mansfield and Southampton Islands and of the southwestern shores of Hudson's Bay and James' Bay, as well as the Devonian rocks of the latter. These flat-lying palæozoic strata probably also extend over much of the bed of the bay, judging by its shallowness and the uniform depth of its waters, and also from the composition of the materials of the drift which have been carried out of it during the glacial period. None of the unaltered rocks around the Bay have undergone any marked disturbance, so far as known. The observations of Dr. Franz Boas and others around Fox Channel would lead us to suppose that from a geological standpoint this body of water is a repitition of Hudson's Bay on a smaller scale (see above).

Nucleus of the continent.

Basin of Hudson's Bay.

Palæozoic strata.

Fox Channel.

The Manitounuck series is largely made up of rocks of volcanic origin and I have obtained specimens of diorites and porphyry from the north-western part of the bay. The probable site of the original source from which these rocks have been derived has not yet been ascertained. A set of immense dykes of trap along the Mattagami River running north ward towards James' Bay, was described in my report for 1875; and other dykes, having the same general course, were found along the east side of James' Bay in 1877. No irregularity has been found in tho bottom of Hudson's Bay which might indicate a seat of volcanic disturbance in former times. The unexplored district behind Cape Henrietta Maria may yet throw some light on this subject. The volcanic rocks of the Manitounuck group of the Eastmain coast and the islands opposite to it may have been originally derived from the neighbourhood of Clearwater Lake to the eastward of Richmond Gulf. Between Lake Superior

Source of volcanic rocks.

Clearwater Lake.

and Hudson's Bay, I have observed that, other things being equal, the water of lakes where igneous rocks prevail, is much clearer than those surrounded by gneiss or schists. The Rev. Mr. Peck visited the lake referred to in 1884, and he informs me that it merits its name from the clearness of its waters.

Schistose bands Schistose bands and areas which have been classified as Huronian are largely developed within the general limits of the Laurentian country to the south and west of James' Bay and apparently also on the northwest side of Hudson's Bay, but to the eastward few indications of these rocks have yet been discovered. **Labrador Peninsula.** The Labrador peninsula measures, as nearly as possible, 1,000 miles from the Straits of Belle Isle due west to the Eastmain coast of James' Bay, by 1,000 miles from Cape Wolstenholme, on Hudson's Straits, to Mingan on the Gulf of St. Lawrence. The interior of this vast region has not yet been explored geologically, except to a very limited extent, so that rocks of the class called Huronian may exist in great force in some parts of it A non-fossiliferous, but unaltered limestone, like those of the Manitounuck group is found around Lake Mistassini near the head of the Rupert River in the southern part of the above region.

The gneissic rocks of the east coast of Hudson's Bay have been described in my reports for 1875 and 1877, and those of Hudson's Straits in the report for 1884. Dr. Frans Boas, in the course of his explorations has made some notes on the fundamental rocks of Baffin Land, which stretches from Hudson's Straits northward through twelve degrees of latitude, or to Lancaster Sound. At page 57 of his report (Dr. A. Petermann's Mitteilungen aus Justus Perthes Geographischer Anstalt, Nr. 80. Gotha. Nov. 1885), he says: "Let us, in conclusion, cast a glance on the geological structure of the last-mentioned territory (the northern part of Baffin Land). The nucleus of the mountain masses appears to be everywhere gneiss, which I found especially at Kinguait **Rocks of Baffin Land.** and Panguirtung. In closest combination with the gneiss, granite, also occurs, which, especially large-grained, appears in the coast ranges and islands.—Anarmtung and Nuvakdjuak in Cumberland Sound; Padloping, Kexertaxdjuin, Nudlung, Tupirbikdjawitjung and Siorartijung on Davis Strait."

"In Cumberland Sound, as well as in the Naguimiut plateau, which latter is mostly composed of fine-grained granites, there are found at isolated places, diorites and trap-granulites which have broken through the granite. The occurrence of these to the south on Blunt peninsula, **Cumberland Sound.** has been confirmed. In Cumberland Sound I found them at Panguirtung and in a well-marked dyke in Akuliaxling eastward from Kexerten. The same diorite appears also in the mountain Kaliugujang to the east of Kinguait."

"The Silurian limestones, overlying the old crystalline rocks, have been already mentioned. The same are found besides in Field Bay, and they compose nearly the whole northern coast of Baffin Land. Hall found sandstone at Lock's Land, which perhaps belongs to the Carboniferous formation. It is said to resemble that found by Parry at Antridge Bay (Fury and Hecla Strait). Here may also be mentioned the samples of sandstone found by Bessils at Point Garry. From accounts by Captain Walker of the ship "Erik," coal is found in loose boulders in a stream at Eclipse Sound and on Aggidjeu (Durban Island)."

Rocks of other northern localities.

The gneissic rocks within the immense area which has been described, no doubt represent a great period of geological time, and comprise a vast thickness of strata, the amount of which it would be impossible to determiue with any degree of accuracy. Certain areas of a massive granitoid character, are regarded as "primitive" gneiss, and there is little doubt they are more ancient than those Laurentian rocks which are regularly and distinctly stratified, and consist of bands of different lithological characters, such as prevail in the Ottawa valley. As a general rule, in the great region around Hudson's Bay, the gneiss is of a very monotimous character, consisting of the commoner reddish and greyish varieties. It is mostly massive, highly crystalline and hard, except where it has been exposed for ages to atmospheric influences, as in the non-glaciated districts. The fresh rock will break almost as easily across the lines of stratification as parallel with them. The average direction of the lamination is sometimes pretty constant over a considerable extent of country, but it is as frequently, greatly contorted on the small scale, and so much disturbed on the large scale as to render it almost impossible to trace out and map its structure. The gneisses of this kind are not known to carry any useful minerals, except such as mica and felspar in coarse granite veins. On the other hand, in the more southern districts, where the gneisses are somewhat regular, and where their different divisions are capable of being mapped, we find phosphate of lime, graphite, limestone, barytes, serpentine, magnetite and hematite, pyrites, gelena, copper ores, &c. These rocks appear to be newer than the massive gneisses which prevail in the north.

Characters of gneisses.

Useful minerals.

The continuity and the geographical compactness of the great metamorphic or Laurentian area of the north-eastern part of the continent are themselves evidences of the close relationship in age of the rocks comprised within it, whereas there is more room for uncertainty on this point in reference to widely separated areas of metamorphic rocks more or less surrounded by newer formations. The various bands of rock which in Canada have been recognized under the name Huronian

Evidences of relationship in age.

all lie within the general geographical limits of the Laurentian country, and are either stratigraphically incorporated amongst the members of the Laurentian series, or present no want of conformity to them. A variety of altered rocks, bearing a strong resemblance to those of some of the Huronian bands are found elsewhere, as in the Eastern Townships and New Brunswick, but their relations to the Laurentian system cannot be so easily determined.

Quartzites of Lake Huron.

The series of rocks on the north side of Lake Huron, to which the name Huronian was first applied, is made up largely of quartzites, but to the north and west of this region these form only a minor portion, or are altogether wanting in the bands called Huronian, and which are composed principally of the other rocks, associated with the Lake Huron quartzites. They consist of more or less massive diorites, argillaceous and dioritic slate-conglomerates, granites and syenites, schistose and jaspery iron ores, limestones or dolomites, and imperfect gneisses, together with a great variety of schists, such as mica and hydro-mica, talcoid, chloritic, dioritic, argillaceous, silicious, epidotic, hornblendic, felsitic and dolomitic. Within the general limits of the Laureantian area, nearly all the metallic ores and other useful minerals, as yet known, have been found in these rocks, and, therefore, their discovery and correct delineation on the geological map are important. As far as our explorations have gone, rocks of these kinds, and which may for convenience be styled Huronian, are much more abundant in the region between the Great Lakes and Hudson's Bay than anywhere in the Labrador peninsula or north of Hudson's Strait. They have been found at three places on the east coast of James' and Hudson's Bay. (See Report of 1877.) Mr. John McLean mentions them south of Ungava Bay. Some of the rocks of Nachvak, on the Atlantic coast, may be classified with them; and they are believed to occur at Ramah and near the entrance of Hamilton Inlet, on the same coast.

Associated rocks.

Useful minerals in Huronian rocks

Geograpical distribution of Huronian rocks.

GEOLOGY OF THE WEST COAST OF HUDSON'S BAY.

Eskimo Point to Chesterfield Inlet.

During the past season I have received from a friend a carefully labelled collection of rock-specimens from the north-west coast of Hudson's Bay, between Eskimo Point and Chesterfield Inlet; and in connection with these a few remarks may be made on the geology of this region. Other specimens from this part of the coast were obtained in 1884 and referred to in my report for that year (page 34 D D.) My own explorations on this coast, beyond Churchill, consist of a boat voyage to a point a short distance north of Button's Bay, in 1879, and

an examination of Marble Island in 1884. The general character of the land about Chesterfield Inlet could be plainly seen from the ship when we were in that vicinity in the latter year. I have, however, received from friends who have travelled in these parts many particulars in reference to this coast. Professor James Tennant, of London, has described some rock-specimens from the north-west side of Hudson's Bay, and also from Repulse Bay, further north. From these various sources of information some light is thrown on the geology of the coast. Marble Island. Prof. Tennant.

Between Seal River and Eskimo Point, a distance of about 140 statute miles, the shore-line appears to be uniform with a low country behind it, broken only by an occasional hummock, probably of drift. The shingle of the beach is said to consist largely of limestone, and it is not improbable that behind this section of the coast, there is a considerable area of the flat-lying limestones, similar to those along the lower parts of the Churchill and Nelson Rivers. If this part of the coast were occupied by crystalline rocks, we should probably have a hilly country with a broken coast-line, like that further north, whereas the low appearance of the land and the even trend of the shore are analagous to the conditions which prevail where the Silurian rocks are met with further south on the Bay. Coast from Seal River to Eskimo Point. Probable area of limestone.

From Eskimo Point to the entrance of Chesterfield Inlet, the distance is about 180 statute miles, in a straight line. The rock-specimens from this section embrace fine-grained hornblende-schists, greenstones, quartz and epidote rock, light grey, coarse-grained sandstone, altered to quartzite, and holding fragments of indurated red shale, compact banded white quartz-rock, with crystals of iron pyrites in some of the layers, quartzite like that of Marble Island, grey felsites, crystalline hornblende-rock, diorite consisting of compact white felspar with long crystals of dark hornblende, banded grey hornblende and quartz-rock, with some layers approaching chert, mica-schists of different kinds, mixed hornblende- and mica-schist, chocolate-colored porphyry with flesh-colored crystals of felspar and grains of clear quartz, granulite, red jasper with dull fracture, hard, brownish-red sandstone, grey felsitic quartzite with lenticular patches of dark mica-schist, chloritic schist, about fifty pounds of granular iron pyrites, several hundreds of cubes of iron pyrites, the largest measuring about one inch in diameter, taken from a dark, glossy schist, quartz veinstone with large scales of light-colored mica, with garnets, calcspar veinstone with embedded crystals of quartz and having grey steatitic rock adhering to it, also a veinstone of quartz, containing silky radiating aggregates of hornblende and a few specks of calcspar and iron pyrites; some soft greenish schist is attached to this specimen. There are eleven specimens of the granular iron pyrites, which Varieties of rocks. Veinstones. Iron pyrites.

were collected at different points in the above distance. Small pieces of soft dark-greenish schist adhere to some of them. Mr. Hoffmann has made an assay of one of the specimens of pyrites from a bay south of Cape Jones, which forms the southern horn of Rankin Inlet, and found it to contain no copper, but to show traces of gold and 0.175 of an ounce of silver to the ton of 2,000 pounds. A specimen of similar pyrites, obtained from a place on this coast which the Eskimo call Iñari, in 1879, had a small quantity of light bluish-grey magnesian limestone adhering to it. These specimens, which all resemble the pyrites from Tilt Cove in Newfoundland and Capelton in the Eastern Townships, except in the absence of copper, are evidently from good-sized veins. The mineral is in common use among the Eskimo for striking fire. The discovery of traces of gold and silver in the specimen last assayed by Mr. Hoffmann is interesting. Specks of gold are mentioned by Tennant in a specimen of quartz from Repulse Bay.

Gold and silver.

Pyrites from veins.

Gold in quartz.

The majority of the lithological specimens brought from the coast in the whole interval between Eskimo Point and Repulse Bay, correspond with the rocks of the Huronian series. Laurentian types are absent from the collections. So far as we know, therefore, the probabilities are that Huronian rocks prevail all along the north-west coast of Hudson's Bay, from Eskimo Point to Chesterfield Inlet, and again at Repulse Bay; possibly also, in the interval between the last mentioned localities.

Huronian series on the N. W. side of Hudson's Bay.

Marble Island, as far as examined, consists mainly of light-colored, fine grained quartzite, associated with glossy mica-schists. Among the specimens obtained from the mainland, is one of similar quartzite of a delicate pink or flesh-color, from a point on the south side of Nevil Bay. On Marble Island the average strike is southwestward or in this direction, so that the two localities may occupy the same geological horizon. White quartzite is reported as occurring further south-west in the interior, especially in the region to the north-east of Hatchet or Wollaston Lake, and in my report for 1882, page 28 C C, it was stated that boulders of this rock are abundant at the Long or Methy Portage, still further south-west.

Quartzite of Marble Island.

Quartzite on mainland.

Quartzite in the interior.

APPENDIX I.

LIST

BY PROFESSOR MACOUN

OF

PLANTS COLLECTED IN NEWFOUNDLAND IN 1885,

BY

DR. ROBERT BELL.

I, Brigus. II, Petty Harbour. III, St. John's. IV, Topsail.

No.		I.	II.	III.	IV.
	I. RANUNCULACEÆ.				
1	Thalictrum Cornuti, Linn				*
2	Ranunculus acris, Linn	*			
3	" repens, Linn	*			
	II. NYMPHÆACEÆ.				
4	Nymphæa odorata, Ait			*	
5	Nuphar advena, Ait		*		
	III. SARRACENIACEÆ.				
6	Sarracenia purpurea, Linn		*		
	IV. VIOLACEÆ.				
7	Viola blanda, Willd	*			
8	" cucullata, Ait				*
	V. CARYOPHYLLACEÆ.				
9	Stellaria media, Smith				*
10	" borealis, Bigel	*			
11	Cerastium viscosum, Linn	*			
12	Sagina procumbens, Linn		*		
	VI. SAPINDACEÆ.				
13	Acer spicatum, Lam				*

No.		I.	II.	III.	IV.
	VII. LEGUMINOSÆ.				
14	Vicia Cracca, Linn				*
	VIII. ROSACEÆ.				
15	Prunus, Pennsylvanica, Linn				*
16	" Virginiana, Linn				*
17	Spiræa salicifolia, Linn	*			
18	Poterium Canadense, Gray	·			*
19	Agrimonia Eupatoria, Linn				*
20	Potentilla fruticosa, Linn	*			
21	" tridentata, Ait	*			
22	Rubus strigosus, Michx	*	*		
23	" villosus, Ait		*		
24	" triflorus, Richards				*
25	Rosa nitida, Willd				*
26	Pirus arbutifolia, Linn		*		
27	Amelanchier Canadensis, T. & G., *var.* oligocarpa, Gray		*		
	IX. ONAGRACEÆ.				
28	Epilobium angustifolium, Linn				*
29	" coloratum, Muhl		*		
	X. DROSERACEÆ.				
30	Drosera rotundifolia, Linn	*	*		
	XI. CORNACEÆ.				
31	Cornus Canadensis, Linn				*
	XII. CAPRIFOLIACEÆ.				
32	Linnæa borealis, Gronov	*			*
33	Viburnum nudum, Linn		*		
34	" pauciflorum, Pylaie				*
35	Lonicera cærulea, Linn	*			
36	Diervilla trifida, Mœnch		*		
	XIII. COMPOSITÆ.				
37	Aster radula, Ait	*			
38	" nemoralis, Ait	*	*		
39	Eupatorium purpureum, Linn				*
40	Solidago uliginosa, Nutt	*			
41	Achillæa Millefolium, Linn		*		
42	Solidago Canadensis, Linn				*
43	Centaurea nigra, Linn		*		*
44	Nabalus serpentaria, Pursh	*	*		*
45	Leontodon autumnale, Linn	*	*		*
	XIV. CAMPANULACEÆ.				
46	Campanula rotundifolia, Linn	*			

No.		I.	II.	III.	IV.
	XV. ERICACEÆ.				
47	Vaccinium Oxycoccus, Linn........	*			
48	" Vitis-Idæa, Linn	*			
49	" macrocarpon, Ait.........................	*			
50	" Pennsylvanicum, Linn....................	*	*		
51	Chiogenes hispidula, Torr. and Gray..................	*			
52	Cassandra calyculata, Don............................	*			
53	Kalmia angustifolia. Linn............................	*	*	*	
54	Rhodora Canadensis, Linn.............................				*
55	Ledum latifolium, Ait................................	*			
56	Pyrola secunda, Linn.................................	*			
	XVI. SCROPHULARIACEÆ.				
57	Euphrasia officinalis, Linn....				*
58	Rhinanthus Crista-galli, Linn....				*
	XVII. LABIATÆ.				
59	Brunella vulgaris, Linn..............................				*
60	Scutellaria galericulata, Ait				*
61	Galeopsis Tetrahit, Linn.............................		*		
	XVIII. BORAGINACEÆ.				
62	Myosotis laxa, Gray..................................		*		*
	XIX. GENTIANACEÆ.				
63	Halenia deflexa, Griesb..............................		*		
	XX. POLYGONACEÆ.				
64	Rumex acetosella, Linn	*			
	XXI. EMPETRACEÆ.				
65	Empetrum nigrum, Linn	*	*		
	XXII. MYRICACEÆ.				
66	Myrica Gale, Linn....................................	*			
	XXIII. BETULACEÆ.				
67	Alnus viridis, D C...................................				*
	XXIV. CONIFERÆ.				
68	Juniperus communis, Linn.............................		*		
69	" Sabina, *var.* procumbens, Pursh....	*			
	XXV. ORCHIDACEÆ.				
70	Habenaria tridentata, Hook				*
71	" dilatata, Gray...........................	*			
72	Spiranthes Romanzoviana, Cham	*			

No.		I.	II.	III.	IV.
	XXVI. IRIDACEÆ.				
73	Iris versicolor, Linn		*		
74	Sisyrinchium Bermudiana, Linn		*		
	XXVII. LILIACEÆ.				
75	Clintonia borealis, Raf	*			
76	Smilacina bifolia, Ker	*			
	XXVIII. JUNCACEÆ.				
77	Juncus bufonius, Linn	*	*		
78	" Canadensis *var.* coarctatus, G	*			
79	" effusus, Linn	*			
	XXIX. CYPERACEÆ.				
80	Eriophorum vaginatum, Linn	*			
81	" Virginicum, Linn	*			
82	Carex sterilis, Willd				*
83	" crinita, Lam	*			
84	" vulgaris, Fries		*		
85	" canescens, Linn	*			
	XXX. GRAMINEÆ.				
86	Alopecurus aristulatus, Michx		*		
87	Agrostis vulgaris, With	*			
88	Agrostis canina, Linn	*			
89	Poa pratensis, Linn		*		
90	Festuca ovina, Linn		*		
91	Triticum repens, Linn				*
92	Aira cæspitosa, Linn		*		
	XXXI. FILICES.				
93	Asplenium Filix-foemina, Bernh				*
94	Aspidium spinulosum, Swz. *var.* Boottii. Tuck	*			*
95	" " dilatatum, Horn	*	*	*	
96	Onoclea sensibilis, Linn				*
97	Osmunda cinnamomea, Linn	*	*	*	
98	" regalis, Linn		*		*
	XXXII. LYCOPODIACEÆ.				
99	Lycopodium dendroideum, Michx	*			
100	" clavatum, Linn	*			
101	" annotinum, Linn	*			
102	" alpinum, Linn	*			
	XXXIII. MUSCI.				
103	Sphagnum fimbriatum, Wils	*			
104	" acutifolium, Ehrh	*			
105	Polytrichum juniperinum, Hedw	*			
106	" formosum, Hedw		*		
	XXXIV. LICHENES.				
107	Cladonia deformis	*			

ADDITIONAL PLANTS FROM LABRADOR AND HUDSON'S STRAIT.

After a careful examination of all the collections made by Dr. Bell in Labrador and on the shores of Hudson's Strait and Bay in 1885, Professor Macoun finds only the following five to add to the list of flowering plants obtained by him in these regions in 1884:—

1. Anemone parviflora, Linn, Port Burwell, Cape Chudleigh.
2. Anemone Hepatica, Linn, Ashe's Inlet, North Bluff.
3. Draba incana, Linn, var. confusa, Poir, Port Burwell, Cape Chudleigh.
4. Rhododendron Lapponicum, Linn, Nachvak, Labrador.
5. Primula farinosa, Linn, Nachvak, Labrador.

APPENDIX II.

PARTIAL LIST OF INSECTS COLLECTED IN 1885, BY DR. ROBERT BELL, IN CONNECTION WITH THE HUDSON'S BAY EXPEDITION.

LEPIDOPTERA,

DETERMINED BY H. H. LYMAN.

Papilio Brevicauda, Saunders. 1♀. St. John's, N.F. This specimen is interesting from the absence of fulvous from the upper side.

Papilio Turnus, Linn. 1♂. Taken at Topsail, N.F.

Pieris Napi, Esp.

Arctic form, *Bryoniæ*, Ochs. ♀, Summer form, *Acadica*, Edw. ♀. Taken at St. John's, N.F. The former is the spring form, and the latter the summer one. The two broods overlap, and specimens of both are thus taken flying together.

Pyrameis Atalanta, Linn. One specimen. St. John's, N.F.

Colias Pelidne, Boisd. Var. Orange ♂. Taken at Hyla on E. side of Hudson's Bay, 30 miles south of Cape Wolstenholme. This is the most interesting specimen in the collection, only one other Orange ♂ having previously been reported, as described Mr. Moschler in Wien. Ent. Mar. IV, p. 354 (1860).

Colias Nastes, Boisd. One specimen of rather small size. Taken at Cape Chudleigh, Hudson's Strait.

Argynnis Polaris, Boisd. Three specimens (2♂, 1♀), Cape Chudleigh. Three specimens, Cape Digges, Hudson's Bay.

Laria Rosii, Curt. Two specimens. Cape Digges.

Anarta Richardsoni, Curt. Two specimens. Cape Chudleigh.

Also several others not yet determined.

COLEOPTERA,

DEMERMINED BY DR. G. H. HORN.

(Per favor of W. H. Harrington.)

Stupart's Bay.

Amara hyperborea, Dej. Over 100 specimens.
Pterostichus hudsonicus, Lec.
Hydroporus longicornis (occurs in Europe).
" *perplexus*, Shp.
Agabus longulus, Lec. (?). 50 specimens.

Cape Chudleigh.

Nebria sahlbergi, Fisch.
Amara hyperborea, Dej.
Lepyrus colon, Linn.

Cape Digges.

Amara hyperborea, Dej.
Agabus longulus, Lec (?)
Criocephalus agrestis, Kirby.

Blanc Sablon.

Nebria sahlbergi, Fisch.
Pterostichus luczottii, Dej.
Quedius sublimbatus, *Mäkl.*

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA
ALFRED R. C. SELWYN, LL.D., F.R.S., F.G.S., DIRECTOR.

REPORT

ON THE

GEOLOGICAL FORMATIONS

OF

EASTERN ALBERT AND WESTMORELAND COUNTIES

NEW BRUNSWICK

AND OF PORTIONS OF

CUMBERLAND AND COLCHESTER COUNTIES,

NOVA SCOTIA

EMBRACING THE

SPRING HILL COAL BASIN AND THE CARBONIFEROUS SYSTEM NORTH OF THE COBEQUID MOUNTAINS.

BY

R. W. ELLS, M.A.

1884.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

Montreal:
DAWSON BROTHERS.

1885.

ALFRED R. C. SELWYN, LL.D., F.R.S.

Director of the Geological and Natural History Survey.

SIR,—I beg to submit herewith my report on the explorations of the past season in south-eastern New Brunswick and in the counties of Cumberland and Colchester in the adjoining province of Nova Scotia. Included will be found the results of a large portion of the work done in former years by Messrs. Scott Barlow, and the late W. McOuat.

My assistants during the past year were Messrs. N. J. Giroux, C.E., P.L.S., and A. E. Barlow, B.A., and for a short time Mr. R. E. Chambers, B.A., of Truro, N.S.

The quarter-sheet map accompanying this report is No. 4, N.W. of the New Brunswick series and completes the map of the southern portion of that province.

The dips and bearings are given with reference to the true meridian, the variation being from 21° to 22° west.

Various papers on the geology of portions of the area included in this report, since the first report on the Geology and Mineralogy of N. S., 1836, by Dr. A. Gesner, have been contributed from time to time, principally by Sir William Dawson. These papers are published in the *Transactions of the Geological Society of London* and in the *Canadian Naturalist*. Their subject matter also forms part of *Acadian Geology*, 1868, and the supplement 1878. Other papers by Dr. Honeyman, and Mr. Gilpin of Halifax, have appeared in the *Transactions of the Nova Scotia Institute of Natural Science*.

The detailed measurements of the Joggins section made by Sir Wm. Logan will be found in the Report of Progress for 1845, and in the *Acadian Geology*, pages 156 to 178.

I have the honor to be,

Sir.

Your very obedient servant,

R. W. ELLS.

REPORT

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EASTERN ALBERT AND WESTMORELAND COUNTIES IN NEW BRUNSWICK

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EMBRACING THE SPRING HILL COAL BASIN AND THE CARBONIFEROUS SYSTEM NORTH OF THE COBEQUID MOUNTAINS.

BY

R. W. ELLS, M.A.

The quarter-sheet necessary to complete the map of Eastern New Brunswick, embraces a considerable portion of the counties of Cumberland and Colchester in the adjoining province of Nova Scotia. A large amount of topographical and geological work had been done in former years, more especially in Cumberland, by Messrs. Scott Barlow and W. McOuat, but the untimely death of the latter and the transference of the former from the field staff to the position of chief draughtsman, prevented the completion of their surveys, and it therefore became necessary, before these could be prepared for publication, to make further explorations in that direction. The present report and map gives therefore, to a large extent, the results of the work done by these gentlemen, in addition to the conclusions arrived at from the observations made during the past season. Work previously done.

To render the map more accurate a number of chained lines were run, principally by Messrs. Giroux and Barlow, in order to connect the work already done with the Intercolonial Railway system extending from Moncton to Truro, and which has been used largely as a base line in its construction.

The area between the Cobequid Mountains and Minas Basin, although not included in the accompanying quarter-sheet map, has been

examined as far east as Truro. This was necessary to complete our sections and to establish our connections between the surveys on the north side of the mountain range and the coast of the Bay of Fundy.

In New Brunswick a large amount of work had also been done in former years in the area included in the accompanying map. As the results of a part of this work have already appeared in the Report of Progress for 1876–77 and 1877–78, the examinations of the past season were confined principally to the country east of the Petitcodiac River, including the copper deposits of Cape Maringouin and Dorchester and the reported coal area north-east of Sackville.

The latter part of the season was devoted to explorations in the vicinity of the Spring Hill Mines, for the purpose of determining the extension of the thick coal seams of that area to the north and west, the results of which will be given further on.

Survey of Casupscull River.

In addition to the explorations in New Brunswick and Nova Scotia, a micrometer survey was made of the Casupscull River, which flows into the Matapedia from the east at thirty-five miles above its forks with the Restigouche. This was done for the purpose of determining the western extension of the inland Devonian basin described in last report (1882–84) as existing in the interior of the Gaspé peninsula. The survey has been plotted and appears on the map of that locality (quarter sheet No. 3 N. W.) accompanying the report first referred to.

The geological systems and formations described in the present report are :—

- Triassic, H.
- Carboniferous.
  - Upper, G 4.
  - Middle, G. 3 and 2.
  - Lower, G 1.
- Devonian, F.
- Silurian, E.
- Pre-Cambrian, A. B., or Cobequid series.
- Post Tertiary, M.
- Igneous rocks.

TRIASSIC, H.

Areas of Triassic rocks are found at intervals along the shores of Minas Basin. They extend for the most part but a short distance inland and have their greatest development in the vicinity of Truro and for ten to fifteen miles west. East of that town they occupy the valley of

the Salmon River for about six miles and extend northward to the second bridge over the North River, about four miles in a direct line from Truro. Thence they occupy the country westward along the line of the Intercolonial railway and for a short distance north, to the vicinity of the Folly River viaduct., where the contact with the underlying Carboniferous formation is seen about 500 yards above the railroad. From this point the area becomes narrower, the northern boundary gradually approaching the shore of the Basin of Minas, which it reaches at Five Islands. The continuity along the coast is broken in the vicinity of Economy by areas of Lower Carboniferous sediments. Below this, towards Cape Chignecto, the Triassic formation occurs only in irregular patches upon the older rocks. The sediments are generally soft and consist of reddish sandstones, shales and fine conglomerates, the latter being found generally near the base. Traces of plant stems were noticed on the shore at Gerrish Mountain. These were too imperfect for determination, but from the character of the rock and the presence of fossils, it is possible that areas of Permo-Carboniferous may occur at this point. The strata are penetrated by trap dykes, often of large size, which, passing upward through the formation, have spread out in sheets and overflows, often of great extent. This is well seen on the shore at Indian Point above Five Island Village, where it constitutes the high ridge of the mountain just mentioned, as well as on the south side of the Bay of Fundy, where it forms the long range of the North Mountains. The contact of the two is also well seen at Cape Blomidon, where the trap rests directly upon the sedimentary beds. At such places the igneous rocks do not appear to have exerted any considerable influence upon the strata in contact, the metamorphism extending in no case, where observed, beyond a few feet.

Character of Triassic rock of Minas Basin.

UPPER CARBONIFEROUS, G. 4.

In the southeastern part of New Brunswick, the Carboniferous system is represented by the three formations, the Upper, Middle and Lower, the Middle, however, in so far as known, being confined to the Millstone-grit portion. These three are well exposed on the shore of the Maringouin Peninsula, which extends southwesterly from Sackville between the waters of Chignecto and Shepody Bays. The strata of the Upper Carboniferous, as developed in this locality, consist generally of soft reddish or purple brown sandstone, grits and shales, which rest unconformably upon the Millstone-grit, or Lower Carboniferous at various points. They occupy the central portion of the Maringouin Peninsula, from the vicinity of Green's Creek to the creek north of Wood Point on the east side, and from Hard Ledge to the lower end of the red

Areas of Upper Carboniferous in Eastern New Brunswick.

bluff known as Dorchester Cape, opposite Hopewell. West of Sackville, they occupy the depression through which the Intercolonial Railway passes towards Dorchester, bounded on the south by the Millstone-grit ridge of Westcock, which separates this area from that just described. The northern limit is defined by the Millstone-grit ridge that extends from Dorchester through Fairfield to the rear of Upper Sackville.

East of Sackville this area is divided by the Aulac ridge, which extends north-easterly from the head of Cumberland Basin to Hall's Hill, with a breadth of about one mile to one mile and a half. Thence, sweeping round the northern extremity of this ridge, the formation extends across the boundary into the neighbouring province of Nova Scotia, where its distribution will be presently described.

About the shores of Bay Verte and on the Tormentine peninsula these rocks have a considerable development. They occupy the greater part of the country to the north-east of Sackville and east of the Aboushagan River, whence they spread out in a thin sheet to Cape Tormentine. They here rest upon the Millstone-grit, the presence of which is indicated by a low ridge of grey sandstone and by numerous blocks of grey grit at intervals along the line of the Emigrant road. Ledges of this underlying formation are well exposed near Bayfield Corner.

Thickness in Maringouin Peninsula.

On the western side of the Maringouin peninsula these rocks have an estimated thickness of 1250 feet. Their most southerly outcrop on the beach is about fifty paces east of Hard Ledge wharf, where soft, brownish-red or purple sandstones rest unconformably upon purple and grey Millstone-grit sandstone and shale, abounding with remains of plants and tree stems, the bark of the latter being frequently changed to coal. At this place they form a shallow synclinal with a breadth of 210 paces and contain a band of blackish limestone six inches thick.

A space of 225 paces then occurs occupied by grey and purple beds, of Millstone-grit age, having a southerly dip at an angle of 35° to 40°, to the axis of an anticlinal and probable fault. The dip then suddenly changes to N. 25° E. $<$ 10°, marking the southern boundary of the principal Upper Carboniferous basin. Thence exposures of these rocks extend up to the mouth of Johnston's Creek, consisting for the most part of brownish-red, and sometimes grey sandstone and shales, some of the coarser beds being a conglomerate from the presence of small pebbles of white quartz. Throughout this distance the dip ranges from 10° to 5°. The western edge of a shallow synclinal is apparent as we approach the Creek, the strata gradually curving round from N. E. $<$ 10° to S. 80° E. $<$ 5° and at the mouth to S. E. $<$ 5°. Thence, for a further space of a mile north, the shores are low and ledges are not seen, but from the character of the soil and drift the underlying rocks are probably of this age.

Distribution about Sackville

At this distance low cliffs of red marly shales of the Lower Carboniferous occur on the shore and are exposed for thirty-five chains. Above this for a further distance of ninety chains no ledges are visible, but from the debris on the road and the general aspect of the country it is probable that Upper Carboniferous beds again come in and extend across the peninsula to Wood Point, on the eastern shore, where they are terminated to the north by the unconformable grey beds of the Westcock ridge. The line of contact is here also probably marked by a fault.

The soil over a considerable portion of this area consists of white sand, and the surface is largely a wet barren. Numerous pieces of sandstone or quartz-grit, of a pinkish-grey colour, are seen, which are probably derived from the upper beds of the formation as here developed.

In the vicinity of Sackville, Upper Carboniferous strata are well exposed at several points. They are well seen in the quarry five-eighths of a mile in rear of that town, on the road leading to Dorchester. The rocks here are principally soft, brownish-red sandstone, containing, in some bands, much white mica. Interstratified beds of conglomerate occur, the pebbles being often of reddish shale, though some layers have pebbles of white quartz. Plant stems of large size are seen and in places much false bedding. The strata at the quarry dip generally S. 32° E. < 15°-20°. They resemble very strongly the sandstones and associated beds of Capes Bald and Tormentine and of Prince Edward Island.

Further west the Dorchester road passes over several ridges of moderate elevation, the rock being the usual soft micaceous sandstones and shales, underlaid by harder greyish-white sandstones, which have sometimes a pinkish tinge and are quartzose. These form a white sandy and gritty soil like that of the area on the Maringouin peninsula. They dip southerly S. 30° E. < 25°-30°, and at a distance of three miles and a half from Sackville, rest upon the yellowish-grey sandstones and coarse beds of the Millstone-grit which form the extension of the ridge north-east from Dorchester. On the road leading from Four Corners to Memramcook, and about two miles from the former place, the contact of the two formations is again seen, whence it extends through the western part of Cookville Settlement and gradually sweeps round to the northward, reaching the Gulf shore near Cape Bald. In the flat country or marsh lying between the town of Sackville and the Aulac ridge, no outcrops are visible, but near its upper end at Midgic, and about twenty rods east of the road at the post-office, there are ledges of impure limestone or a calcareous conglomerate of a brownish-red colour, apparently underlying greyish sandstones tinged with red. These are well exposed in a small quarry at this place. Half a mile east, at a saw-mill on a small brook, soft reddish and grey shales and sandstones dip S. 65° E. < 2°-5°, with much false bedding. The same kind of rock is

seen in the cellar of the Midgic P.O., with a dip of S. 40° E. < 20°. All these beds undoubtedly belong to the Upper Carboniferous. Thence on the road to Bristol, at the crossing of the Bill Harper Brook, soft, dark-red sandstones with white mica dip S. 40° E. < 10°. They contain plant stems and resemble the beds near Sackville. From this point to Bristol, exposures are very rare, but at Anderson's Mill Brook large pieces and possibly ledges of soft brown sandstone occur about forty rods below the road, and a pit sunk through the clay at the mill discloses the same soft rock about four feet from the surface.

Tormentine Peninsula.

On the Coburg road, which is a new road turning off south-east about half-way between Midgic and Bristol, at about one mile and a quarter east of the main road, a small seam of coal was found on the bank of a brook, the west branch of the Gaspereau River, which flows into the head of Bay Verte at Port Elgin. This seam was reported to have a thickness of eighteen inches of coal. On testing it, however, the whole thickness of coal and black shale was found to be about nine inches, of which from three to four inches were dirty coal. The associated rocks are greyish sandy shales, and the seam is underlaid by grey clay. It probably belongs to the underlying Millstone-grit formation, and is the extension of a seam found on the Aboushagan River, and to the east of Shediac. Blocks of grey sandstone, but no ledges, were seen on the road to Bristol in the vicinity of Square Lake. The Upper Carboniferous is probably very thin at this place.

Along the shore below Bristol, at Little Shemogue, soft brownish-red sandstones like those of Capes Bald and Tormentine occur, the undoubted representatives of the Upper or Permo-Carboniferous, which thence extend eastward to the extremity of the peninsula.

The greater portion of this peninsula, between Northumberland Strait and Bay Verte, extending from Port Elgin to the extremity, is generally low and level, the highest elevation being Mount Pleasant, which is probably not much more than 150 feet above the sea. Over this area, exposures are almost entirely wanting, and the nature of the underlying rocks can only be determined by the character of the soil. Three miles east of Port Elgin, on the Emigrant road, an opening for a quarry discloses the presence of soft reddish-brown sandstone, dipping S. 30° W. < 3°. Eastward of this, along the road for a further distance of seven miles, the surface is strewed in places with blocks of grey sandstone, which probably mark the presence of an underlying ridge of Millstone-grit, but beyond this point the soil again resembles that of the Upper Carboniferous, and near Mr. Buskirk's house, at Bayfield Corner, the reddish beds rest upon the underlying Millstone-grit sandstone and conglomerate. Two miles south of this, soft dark red sandstones dip easterly < 7°-10°, marking the southern side of the Tormentine anticlinal.

The road along the north side of Bay Verte shews the soft red strata of the Upper Carboniferous on the shore, at intervals, to within about five miles of Port Elgin. The soil then becomes greyer, and blocks of grey sandstones, probably of Millstone-grit age, extend thence to the head of the Bay. In the vicinity of Port Elgin also, and for two miles and a half on the road to Bristol, the soil and loose pieces are grey, beyond which reddish tints prevail and extend thence to the Strait shore.

On the roads extending north from the Emigrant road to Mount Pleasant and Murray's Corner, a narrow belt of greyish soil, covered with greyish blocks, occurs with a breadth of about half a mile. This probably marks the direction of the Tormentine anticlinal, but the lack of exposures renders accurate delineations impossible.

Between Port Elgin and Tidnish River the country is occupied by the soft reddish rocks of Upper Carboniferous age, easily recognized by the scattered blocks and the character of the soil. This is the northern portion of the great area which extends continuously from beyond Sackville.

Passing the Aulac ridge, which is a prominent feature in the otherwise flat country between Sackville and Amherst, we reach the basin of the Missequash and Laplanche Rivers, the former of which marks the boundary between the two provinces. These are probably occupied by Upper Carboniferous rocks. They appear at Amherst in the vicinity of Christie's factory on the Intercolonial Railway, the strata being soft brownish-red sandstone, with pieces of red shale, identical in character with those of Sackville, and dipping N. 10° E. $<$ 8°. This indicates the southern side of the Amherst synclinal. Further east on the road to Leicester, soft brown micaceous sandstones and shales are seen on the Nappan River above Curran's mill. They can thence be traced along the road by the soil and debris for a further distance of one mile and five-eighths, where they rest unconformably upon limestones and shales of Lower Carboniferous age, the Middle Carboniferous being, in so far as can be ascertained, absent in this direction. **Amherst and vicinity.**

North-east from Amherst, on the Tyndal road, which extends to the Strait shore at Tidnish, similar soft strata are exposed near the point where the post-road to Pugwash turns off easterly, and dip northerly at a low angle. Brownish-red sandstones are also seen at a brook about one mile further north, but the dip could not be determined. Between this and the shore of Bay Verte the country is but little above the level of the sea, the soil is reddish and sandy, with frequent barrens and without exposures. The shore of Northumberland Strait, from Tidnish River to Pugwash Harbor, and the country for some dis- **Area north-east of Amherst.**

tance inland, is occupied generally by soft brownish micaceous sandstones and shales which belong to the Upper Carboniferous formation. They dip northerly where examined, at low angles, but exposures inland are exceedingly rare, the softness of the strata causing them to disintegrate very readily. The southern boundary of this area, from the contact with the Lower Carboniferous noted on the road south-east of Amherst, extends in a general easterly direction, crossing the Leicester road about six miles from the forks with the old Economy road, whence it keeps a short distance to the south of that road and crosses the Pugwash River about half a mile above the village of Pugwash, where contacts with the underlying limestones and associated strata of Lower Carboniferous age are seen.

Pugwash to Wallace River.

On the west side of Pugwash Harbor, according to the late Mr. McOuat, ledges of rather coarse dark grey or brownish-grey sandstone, with scattered grains of reddish felspar, occur. Other associated beds of greenish-grey calcareous grit dip N. 20° W. $<$ 38°, but change a little further west to $<$ 25°. Thin limestones and limestone conglomerates occur about one mile from the end of the ferry opposite Pugwash, along with massive brownish-grey freestone. The most westerly exposures on this part of the shore are reddish shales with grey coarse sandstone, containing grains of reddish felspar and small pebbles of vitreous quartz, dipping N. 20° W. $<$ E. 26°.

Between Pugwash and Wallace Harbor, dull brownish-red sandstones, with brick-red shales, the whole, with a few exceptions, micaceous and laminated, occur. About two miles east of the former place these dip N. 5° W. $<$ 28°, changing three miles further east to N. $<$ 26°. A small seam of coal is reported from this latter point, but is unimportant. These rocks occupy the coast to the extremity of the point, and apparently the area north of the Wallace Harbor.

Wallace River.

On the Wallace River, on which a section was made from the foot of the Cobequid Mountains to near its mouth, the rocks of this formation are well exposed. Lower Carboniferous conglomerates and sandstones are seen in the river and on either side at intervals for two miles and three quarters below the road to Wentworth station. Resting upon these are soft brownish-red sandstones and shales, dip N. 5° W. $<$ 10°, which are identical in character and aspect with the beds of the north shore. These are exposed for nearly five miles, the beds gradually declining in dip to the centre of the synclinal, about two miles below their first exposure. The thickness of the measures here seen, assuming an average inclination of 7°, would be about 1,200 feet. Below this point the strata dip southerly at low angles till they rest unconformably upon hard sandstones, shales and conglomerates of Lower Carboniferous age, which dip S. 40° E. $<$ 40°. These lower beds have a breadth

of about three miles, extending for thirty-five chains below Kerr's mill, where the soft brownish beds of the formation under discussion again come in, dip N. 45° W. < 25°, the dip of the Lower Carboniferous at the contact being N. 20° W. < 70°. Thence the dip of the upper beds rapidly declines to 10°, and they apparently extend to the shore of Northumberland Strait. In this section also, no trace of the Middle Carboniferous is visible, the Upper resting in every case directly upon the Lower.

West of the Wallace River, exposures are very rare. The character of the soil, however, indicates that the basin just described extends in this direction between the Intercolonial Railway and the Victoria Settlement beyond the road from Thompson station to Pugwash.

The Port Philip and Pugwash Rivers do not afford good sections, intervals of marsh being frequent; but further east, on the French River, the measures just described are well exposed. The character of the country between the latter stream and the Wallace River indicates that the Upper Carboniferous basin is continuous in this direction. A paced section was made of the French River, from the New Annan road to the vicinity of Tatamagouche Harbor.

French River.

The rocks at the bridge on the New Annan road are green schists and slates, which extend below the road for 200 yards. Red brownish hard sandstone and red conglomerates of Lower Carboniferous aspect then occur and form a narrow band for 100 yards, and are succeeded by grey freestone and grit, with abundance of plant stems, which dip N. < 25°. These strongly resemble beds of Millstone-grit age, but may mark the lower beds of the Upper Carboniferous, as they conform closely in dip to the overlying strata of soft brown-red sandstones and shales of the latter formation, and which come in a short distance below. The dip of these latter is N. 5° W. < 25°. Interstratified beds of fine conglomerate occur with the sandstones, but their bulk is small. The brownish-red sandstones, grits and shales, with occasional grey beds, thence extend down to the shore of Tatamagouche Harbor. The dips are all low, ranging from 20° in the upper part to 5° in the lower, or to perfect horizontality. Copper deposits occur at several points in the form of nodules of grey copper ore or copper glance, associated with plant beds, and have been opened at two places, the upper of which is three quarters of a mile below the New Annan road; the lower, one-fourth of a mile below the road at Porteous' mill. The deposit, however, is probably too limited and uncertain to possess much economic value, and operations have been suspended for some years.

Thickness of formation.

The exposed breadth of these rocks on this stream is about five miles and a half, the dip is generally north, the strike being at right angles to the course of the stream. Assuming the average dip of the measures as 7°, the thickness of the formation here would be about 3,000 feet.

Our surveys in this direction were bounded by the road from Tatamagouche to Truro. On this road, north of the mountain, the soil and debris are similar to those of the areas first described, showing the further extension of this formation towards the Waugh River. On this stream, rocks, with deposits of copper ore, similar to those seen on French River, are observed. From the reports of Sir William Dawson it is evident they extend into Pictou county.

Cumberland county.

A second area of Upper Carboniferous rocks in Cumberland county occupies the country between the Joggins shore and the Spring Hill Mining Company's property. The formation as exposed in the cliffs along the the eastern shore of Chignecto Bay has been described in former reports, 1845, by Sir Wm. Logan, by whom the first measured section was made. This was subsequently revised by Sir Wm. Dawson, who re-examined the section in 1852 in company with Sir Chas. Lyell, and who has since devoted much time to the study and working out of the strata there exposed. The result of his measurements and re-examinations are given in the Acadian Geology, page 157.

The Upper Carboniferous as there described is divided as follows:—

		FEET.
Division 1.	From Shoulie to vicinity of Ragged Reef....	1,617
" 2.	Ragged Reef and vicinity........................	650
" 3.	Vicinity of Ragged Reef to McCairn's Brook.	2,134

The latter division is stated to contain the upper part of the Middle Coal formation, and is, perhaps, equivalent to the Upper Coal formation of the American authors, as it was also so regarded by Sir Wm. Logan.

The rocks of Div. 1, or the upper portion, are thick-bedded white and grey sandstones, passing in some places into a conglomerate with quartz pebbles, and with interstratified beds of reddish and chocolate shales, the sandstones predominating. Fossils are not very numerous, and conifers and calamites are the most abundant.

In Div. 2, the rocks are also white and grey sandstones, with occasional reddish beds and red and grey shales, the sandstones and shales in nearly equal proportions. Under clays occur at two levels. As in division 1, fossils are not numerous.

Division 3 includes 1009 feet of sandstone, almost all of which is grey, and 912 feet of grey and reddish shale and clay. It contains a number of beds of coal, all of small thickness and generally of coarse quality. No seams of economic value have yet been discovered.

The rocks of this formation form a basin of considerable size, whose southern border extends eastward probably from the vicinity of Sand River on the shore to within three miles of the Spring Hill mines. Thence it sweeps suddenly to the north-east and crosses the line of the Intercolonial railway a short distance west of Spring Hill junction.

It then curves again to the eastward and extends up the valley of the Little Forks River to a point about half a mile east of the old Economy road leading to Amherst.

This basin is apparently underlaid on the north by rocks of the productive coal measures, and on the south by those of Millstone-grit age. From McCairn's Brook on the Joggins shore the northern boundary extends eastward in a nearly direct line, crossing the Intercolonial Railway about one mile south of the Maccan station, whence it extends north-easterly up the north side of Little Forks River to the point already indicated. The southern boundary on the coast is not yet definitely fixed, but is probably, as stated, not far from the mouth of Sand River. Between this and Spring Hill it is difficult to trace, owing to the great covering of drift, but as nearly as can be ascertained it crosses the Maccan River not far from Harrison's inn, or about two miles and a half north of Southampton Corner. The breadth of the basin at this place is about five miles.

Extension of the Joggins area.

Owing to the soft nature of much of the rocks of this formation, ledges are rarely met with. The surface is generally a reddish-brown, sandy loam, except where the grey sandstones of the Ragged Reef band occur, the decomposition of which produces a grey, quartzose, sandy soil, differing in character somewhat from that derived from the Millstone-grit, the beds on the whole being harder and more siliceous.

What are apparently the lower members are seen in the cuttings on the railway near the crossing of the Little Forks River, and on several of the roads in that vicinity. They consist of soft brownish-grey sandstones and shales, with layers of fine-grained flaggy grey sandstone, and resemble closely the rocks of the northern area already described. Similar strata with a greater thickness of grey beds occur along the Little Forks River. The relations of the productive and upper formations to the Millstone-grit suggest the presence of a fault along the upper part of this stream, the extent of which cannot be satisfactorily determined.

On the Maccan River and westward along the River Hébert, grey sandstones of the Ragged Reef band are well exposed, indicating the upper part of the formation, and occupy the centre of the synclinal.

Centre of basin.

The inclination of the strata is generally low or from horizontality to ten degrees. The centre of the basin is probably in the vicinity of Reed's Brook, one mile and a half south of the junction of the Little Forks with the Maccan River.

Along the southern side of the basin, the Upper Carboniferous rests upon the Millstone-grit at all observed points, no trace of the productive measures being visible. This may be due to simple overlapping or to the presence of faults, probably to some extent the latter, since

Contact with Millstone-grit.

extensive indications of faulting are seen in the Spring Hill area and along the several streams flowing westward from that locality. These will, however, be described further on.

MIDDLE CARBONIFEROUS—*Productive Measures, Millstone-Grit.*

Following the plan pursued in describing the preceding or Upper Carboniferous formation, we will first state the extent and distribution of the Middle Carboniferous in the portion of New Brunswick embraced in the map, and then take up in detail the structure, in so far as it can be ascertained at present, of the Spring Hill basin and adjoining areas.

In New Brunswick, the result of the examination of the last few years has been to confirm the statement made in former reports, that the Middle Carboniferous was probably confined to the lower member, and that if the productive measures were at all present, their distribution was exceedingly limited. That such is the case in the portion of the map accompanying this report is very evident.

Character of beds in New Brunswick. The rocks of the Millstone-grit differ greatly in their general aspect from those of the productive measures. Lithologically they present greater resemblance to those of the Upper Carboniferous. Throughout the measures, the grey grits, which are often hard and fine-grained, contain beds of chocolate or purple colored slate and sandstone, and in their lower portions, beds of greyish conglomerate, largely made up of white quartz pebbles, and of considerable thickness. The purple beds differ from those of the Upper Carboniferous just described in their greater hardness and coherence and in the general absence of the large scales of yellow and white mica so abundant in the upper formation, as also in their darker shades.

The general distribution of these rocks in central and eastern New Brunswick has already been given in the published reports and map. In general their inclination is slight, but along the coast of Shepody Bay the dip of the beds rises to the vertical, indicating a period of considerable disturbance and probable faults. In eastern Albert and Westmoreland, their distribution is exceedingly irregular, exhibiting well the extensive denudation to which they have been exposed.

Coast from Shepody River to Cape Enragé. Along the southern coast of Albert county the formation extends in a narrow belt from Cape Enragé to the mouth of the Shepody River, with an average breadth inland of half a mile. At New Horton the dip is S. 70° E. $<$ 60°, which course is generally maintained to the extremity of Cape Enragé, the angle of dip increasing midway to 80°–90° with a local anticlinal, the strata for a short distance dipping northwesterly $<$ 85°. The rocks of the greater part of this distance are grey sandstone, grit and fine conglomerate, with occasional beds of

greyish shale. The sandy beds are often beautifully ripple-marked and plant stems and large trunks of trees are common. In places irregular streaks of coal are seen from half an inch to two inches or more in thickness, and have been considered, by some persons, of economic value. In all cases examined the coal is simply the carbonized bark of probably drifted tree trunks. Below Two Islands Cove, thin beds of purple shale and sandstone occur with the grey.

Near the mouth of the Shepody River, the rocks of this formation have a greater superficial development, sweeping inland as far as Harvey Corner. In this area, traces of coal, the carbonized remains of tree stems, are found, and have led to the expenditure of small sums in the vain hope of finding a workable seam. Leaving the mainland, the Maringouin Peninsula. formation includes Mary's Point and Grindstone Island, at both of which places there are extensive quarries. Crossing the waters of Shepody Bay to Cape Maringouin, its continuation rests upon Lower Carboniferous red marls, a short distance above Flagging Reef Cove, or about half a mile north from the southwest extremity of the cape, the beds at the contact dip S. 10° W. $<$ 40°, the underlying red marls dipping S. 15° E. $<$ 50°. The lower beds of the Millstone-grit here consist of purple sandstone and shales with layers of grey grit, admirably adapted for grindstones, which have been and still are quite extensively quarried.

The formation strikes across the end of the Maringouin Peninsula and appears on the eastern coast on the north side of the North Joggins Cove, which is the indentation to the south of Peck's Point. Thence, crossing the Cumberland Bay, it reaches the coast of Nova Scotia at Boss Cove, where the contact with the Lower Carboniferous is again seen. A second area, north of Cape Enragé, separated from Second area in Southern Albert Co. that just described by a belt of Lower Carboniferous rocks, occupies the eastern shore of Salisbury Bay, where it has a surface breadth of three miles and a half, partially concealed, however, along the coast by overlapping Triassic sandstone. It extends north-easterly for six miles to the eastern extremity of the New Horton Lakes, and is probably a thin irregular capping on the underlying Lower Carboniferous. But a third and more extended area occurs further north, flanking the Third area. south side of the Caledonia Mountain range, and stretching from the vicinity of Herring Cove below the Upper Salmon River, with few interruptions, due probably to unequal denudation and possibly local faults, across the central and southern portions of Albert county and eastern Westmoreland to the Strait of Northumberland. The outline of this belt is very irregular from the generally horizontal position of the strata and the extensive denudation.

West of Hopewell Corner, one-eighth of a mile below the road lead-

ing to New Ireland, hard grey sandstones, much broken, contain a small deposit of manganese, long since worked out. On the New Ireland road, the sandstones are associated with conglomerate, and dip S. 65° E. < 20°. These rest upon the crystalline rocks of the mountain about one-eighth of a mile south of Crank Hill Brook. Near the Germantown road they are much broken and indications of a fault are plainly seen.

Fault at contact of Millstone-grit and Lower Carboniferous. Further west, where the second road turns north from the Germantown road at the lower end of the lake, the Millstone-grit and Lower Carboniferous are in contact, both formations dipping southerly, with the Millstone-grit underlying, plainly indicating a fault and an upthrow of the Lower Carboniferous. The rocks of the lower formation thence occupy the road westward to the rear of the Owl's Head Mountain, where they again shew in ledges and extend thence to Salmon River, five miles distant.

East of Hopewell Corner, on the road from Riverside to Caledonia Mountain, ledges of Millstone-grit sandstone are seen at intervals as far as the road leading across to Chester, the dips, where noted, being S. 65° E. < 5°–30°, and the exposed breadth three-fourths of a mile. On the Chester Settlement road, one mile and three-eighths east, they appear in a narrow outcrop near the upper end of the settlement, which marks the eastern termination of the Millstone-grit in this direction. It is probable that the formation, as here developed, occupies the centre of a shallow synclinal in the Lower Carboniferous, as this structure is apparent in the lower formation on Sawmill Creek in rear of Hopewell Hill.

East of Hopewell Hill, on a road which runs north-easterly through Woodworth Settlement, the continuation of this belt is again seen. Blocks and ledges of Millstone-grit sandstone occur one mile distant from the forks of the road leading to Curryville, and thence occupy the road, which runs for the greater part through woods, nearly to the cross road leading out to Demoiselle Creek. On the road from Hopewell Hill to Curryville, they are first exposed on the summit of the ridge in rear of Shepody Mountain, and extend thence to the Creek road, sweeping round the northern and eastern flanks of the mountain, and down the valley to the mouth of the stream. The beds are nearly flat, dipping S. 30° E. < 5°–10°. **Curryville quarries.** The celebrated Curryville quarries occur in this belt. East of this, between the Demoiselle Creek and Petitcodiac River, this formation occupies the greater part of the country, forming a ridge of considerable elevation, and extending northward uninterruptedly to the road leading from Lower Hillsborough to the Albert Mines. North of this, in the vicinity of the gypsum quarries, it occupies irregular areas capping the Lower Carboniferous hills. Their contact on the Petitcodiac River is well seen

just below Edgett's Landing, in the cliff opposite the end of the road to the mines. The grey sandstones and conglomerates here rest upon the red marls with very little appearance of unconformability, both series dipping S. 20° E. $<$ 5°–10°, though several faults of small extent are visible in the face of the cliff. Contact of formations on Petitcodiac River.

North of the great ridge of the Caledonia Mountains, the belt of Lower Carboniferous rocks which include the Albert shales extends continuously for many miles to the Petitcodiac River. These have been fully described in Report of Progress, 1876–77, and in the map accompanying that report, the general outline of the Millstone-grit northward is given. The formation has its southern boundary on the west side of the Petitcodiac about one-fourth of a mile north of Stony Creek, whence it extends with a gradually increasing westerly direction to the Irving Settlement P. O., in Baltimore, beyond which its distribution has already been given in the published maps of Southern New Brunswick. Northward it extends continuously to the Strait of Northumberland. Extension of boundaries.

In the peninsula between the Petitcodiac and Memramcook Rivers, the Millstone-grit is developed in a long irregular area, extending northward from Folly Point, which is the southern extremity. In the vicinity of Rockport and Boudreau villages, large quarries have existed for many years, and the formation occupies the surface from shore to hore, but north of this it recedes from the coast on either side and with a curving outline extends through the centre of the peninsula to the rear of St. Joseph College, about two miles from Memramcook Corner. Another small outcrop, capping the Albert shales and red marls, is seen on the road a short distance south of Beliveau Creek. Memramcook and Petitcodiac Rivers.

The southern boundary of the main area, which has been stated to occur near Stony Creek on the Petitcodiac River, reaches the east bank about one mile north of Dover P. O., whence it curves eastward in an irregular line to the vicinity of Calhoun's mill on the Memramcook River, which stream it crosses about three miles and three-quarters north of Memramcook Corner. Thence it bends southerly and crosses the Beechhill road one mile and a half east of the latter place.

Between this and Dorchester the outline is very irregular, the formation being nearly horizontal and occupying the high lands, while in the valleys the Lower Carboniferous has been exposed by denudation. Two and a half miles below Memramcook station, the Millstone-grit ridge comes nearly to the railroad and the easily disintegrating conglomerates of the lower portion have been extensively quarried for ballast. It, however, recedes up the Valley of Breaux's Creek or Anderson's Mill Brook, and curves round to the rear of the Squirrel Town settlement, at which place the Dorchester copper mine is located. Dorchester and vicinity.

Thence it trends southwesterly and forms a bold escarpment which comes to the vicinity of the Memramcook River, near Dorchester Corner. The extension of the area northward passes about one mile and a half in rear of Upper Sackville and occupies, so far as can be determined, the entire surface to the Northumberland Strait, west of the Aboushagan River.

Maringouin Peninsula area. On the Maringouin Peninsula three bands of Millstone-grit are seen. The most southerly, occupying the extremity, has been already described. The second is well exposed in the vicinity of the roads which cross from Upper Rockland to Hard Ledge, and rests upon Lower Carboniforous red marls and sandstones forming the north side of the great anticlinal which occupies the portion of the Peninsula to the south. The breadth of this area is about three-fourths of a mile, extending along the east shore from Harvey Creek to Green's Creek. At the contact, the two formations are apparently nearly conformable, the Lower Carboniferous dipping N. 30° W. $<$ 70°–80°, while the lowest beds of the Millstone-grit dip N. 25° W. $<$ 75°. At the eastern extremity of this belt, the beds appear to extend northeast in the direction of Aulac, the ridge at which place being directly in the continuation of the strike of that just described. The anticlinal structure of this ridge is seen by contrasting the dips at the two extremities. At Aulac, the dip is S. 65° E. $<$ 35°, while at Hall's Hill, where the ridge terminates, it is N. 45° W. $<$ 10°–20°. The third area on the Maringouin Peninsula is continuous on the western side with that which reaches the river at Dorchester. **Extensions north-east.** Its southern margin is at Dorchester Cape, three miles and a half south of the village, the contact with the Lower Carboniferous being well exposed on the shore. Eastward of this point it forms a prominent ridge which includes the Settlements of Westcock and Second Westcock, and terminates at the mouth of the Tantamar River. At the eastern extremity, the rocks dip N. 10° E. $<$ 80°, and they apparently overlie the Upper Carboniferous of Wood Point, the beds of which lie in a nearly horizontal position. There is evidently a fault of considerable extent in this vicinity, by which the lower beds are brought into their present position.

Coast of Northumberland Straits. The country to the north of Memramcook and Dorchester, and extending to the Northumberland Strait, is occupied by the rocks of this formation, which are the extension of the great area in the vicinity of Moncton, and which continue thence to Shediac. Coarse grey grits, sandstone and pebbly conglomerates shew at intervals in a nearly horizontal position. Near Cape Bald chapel, the soft reddish beds of the Upper Carboniferous come in and overlap the lower formation. The country is generally sandy and uninteresting. Several out-

crops of coal are reported along the northern margin, one of which, near Tidnish or Dupuis Corner, has been referred to in Report of Progress, 1880–81, page 6D. What is probably the extension of the same seam is seen on the Aboushagan River, where it is exposed in the bed of the stream for some distance. Its further extension on the Cobourg road has already been noted. The general thickness of this seam is from two to four inches only.

Eastward, in the Tormentine Peninsula, the occurrence of a low ridge of grey sandstone of this age, terminating at Bayfield, has already been referred to in the section on the Upper Carboniferous. This anticlinal is probably the extension of that seen on the Aulac ridge.

In the formation just described, minerals are rare. Extensive deposits of excellent building stone are however found at various points, some of which have been worked on a large scale for many years, and will be referred to under the head of economics. Traces of copper are found at several places, among which may be mentioned Cape Enragé, New Horton and several points on the Maringouin Peninsula. At all these the quantity of ore is inconsiderable and the deposit of little or no economic value. The largest, and by far most important location, is that known as the Colonial Copper Mine, about three miles and a half north-east of Dorchester. At this place the escarpment of Millstone-grit, which extends north-east from Dorchester, rests upon red marly shales of Lower Carboniferous age, for some distance. The existence of the copper, which occurs near the contact of the two formations, was first discovered by the presence of bare spots on the hillside, where the vegetation had been apparently destroyed by the action of some mineral solution. Upon examination of the locality, deposits of grey copper ore (copper glance) with much green carbonate were found in the lower beds of the grey sandstone and conglomerate. The ore was especially abundant and rich where the plant stems were numerous. The face of the escarpment was carefully prospected, and the ore found at intervals for a mile and a half. During the past year a company has commenced its systematic extraction. Commodious buildings have been erected, and improved mining and hoisting machinery introduced. At the time of my visit in October, forty-five men were employed, the men working in shifts of eight hours each, and a large quantity of hard grey silicious sandstone had been taken out. A portion of this contained plant stems upon which the copper was deposited, and the remainder was stated by the manager to carry from 4 to 5 per cent. of copper glance in a fine state of division, scarcely visible to the naked eye. The quantity of nodular ore in connection with the plant remains did not seem sufficient to war-

Minerals.

Dorchester copper mine.

rant the expenditure of much capital, but if some process of concentrating the disseminated ore from the sandstones can be made available on the spot, a considerable quantity of copper should be realized. Experiments to this end are now being made by the manager, the results of which have not been made public. In the bottom of the shaft, which had a depth of 100 feet, the red marls of the Lower Carboniferous had been reached. The two formations were entirely unconformable, the upper dipping S. 30° E. $< 25°–28°$, while the lower was inclined at a very high angle.

Indications of this deposit are found further east at Beech Hill, in rear of the Four Corners, which would give it an extension of from four to six miles.

Albertite.

Albertite is found in limited quantity in the rocks of this formation at several places. The most important yet noted is at the East Albert Mining Company's property, one mile and a half west of Edgett's Landing, in Lower Hillsboro.' This locality was worked for a time some years ago, but finally abandoned, probably from the lack of material. In the other cases the mineral is present only in small strings and disseminated grains.

It will be seen from the foregoing remarks that the productive portion of the Middle Carboniferous is entirely wanting in this area. The productive measures of the South Joggins in Nova Scotia strike too far south to reach the coast of New Brunswick, and only a portion of the Millstone-grit series, representing the beds probably as high as the grindstone quarries of Seaman's or Lower Cove, is found at Maringouin and the coast from New Horton to Cape Enragé.

Thickness in vicinity of Dorchester.

The thickness of this formation as developed on the shore south of Dorchester from the contact with the Lower Carboniferous beds of Dorchester Cape to the centre of the synclinal, in the vicinity of the Intercolonial Railway, is about 1,000 feet. The exposures, after leaving the cliffs along the shore, are limited, but in a quarry about half a mile south of the railway the beds are nearly flat. This point probably marks the centre of the basin in this direction, the northern slope of which terminates at Dorchester Corner, where the dip of the grey conglomerates is S. 35° E. $< 30°$.

Joggins section.

In the adjoining Province of Nova Scotia, both divisions of the Middle Carboniferous are well represented. The typical section given in the Acadian Geology makes the thickness of the productive measures to be 2,539 feet, and they are stated to extend from McCairn's Cove to the high cliff beyond Coal Mine Point. The rocks are principally grey sandstones and grey and dark-colored shales. The formation contains a number of coal seams, the greater part of which are, however, too thin to be of economic value; but in the vicinity of the South Joggins

several seams occur which have been worked somewhat extensively for many years. The character of the measures and their contained coals have been so minutely given in the report of Sir Wm. Logan, 1845, and subsequently by Sir Wm. Dawson, in the Acadian Geology, 1868, that it is not considered necessary to devote further time to their description.

Divisions and thickness of the formation.

The lower or Millstone-grit portion of the Middle Carboniferous is, in the work already referred to, divided into three sections. The first portion consists of reddish shales and red and grey sandstones, without seams of coal and with a thickness, according to Sir Wm. Logan, of 2,082 feet. It represents the upper part of the Millstone-grit.

The second division has many beds of coarse sandstone and much red shales and contains nine thin seams of coal. The thickness of this division is 3,240 feet. The third division consists of red and chocolate shales with red and grey sandstones, conglomerates and thin beds of concretionary limestones, forming the base of the formation and having a thickness of 650 feet. It may be mentioned that a remeasurement of the measures was made by Mr. Scott Barlow in 1875, but without appreciably changing the thicknesses of the various formations as above stated.

Faults on south side of Joggins Basin.

In the sections given, the northern side of the synclinal has in all cases been examined. The same regularity of measures does not appear on the south side, and, in fact, with the exception of several small seams, most of which are near the base of the Millstone-grit, no traces of the numerous coals seen in the Joggins section are to be found in this direction. It is probable that this area is profoundly affected by faults, indications of which are visible at several points.

Extension of the productive measures of the Joggins area.

In the vicinity of the South Joggins, the productive measures have a superficial breadth of about two miles, their dip being regular throughout. They extend eastward in a band of uniform width for eighteen miles, and, in so far as can be ascertained, terminate a short distance east of the Economy Road, on the Little Forks stream, being cut off in this direction, probably by faulting, as they come abruptly against what is considered to be a ridge of Millstone-grit. They are overlaid to the south by the Upper Carboniferous of the Little Forks and Maccan Rivers already described. Along the northern margin a number of mines are located on what is the extension of one of the thicker Joggins seams, but as these have never been traced continuously, it is exceedingly hazardous in the present state of our knowledge to affirm decidedly on which particular seam these collieries are placed, since they are known to change their character at various points.

It seems, however, probable from the explorations of Messrs. Barlow

and McOuat that the mines east of the Maccan, viz., the Scotia, the Chignecto, the St. George, and further east the Styles mine, are all on the same seam.

Spring Hill area probably distinct from the Joggins area.

The southern side of the synclinal of the productive measures, if not entirely cut off by faults, is overlapped by the Upper Carboniferous already described as resting on the Millstone-grit formation of the Maccan River and west of Spring Hill, as no traces of it can be seen in this direction throughout all the area east of the Joggins shore, and it does not appear to be in any way connected with the productive measures of the Spring Hill mines.

The presence of several seams of coal in this latter area, embracing at least five of workable size, ranging from four to thirteen feet in thickness, renders this section one of the most important mining centres in the province. It was deemed advisable, therefore, to make some further examination of the country to the north and west, with the view of determining, if possible, the extension of these great seams in this direction, and also to make available for publication the great amount of work done in previous years by Messrs. Barlow and McOuat, to the former of whom belongs a large portion of the credit of tracing out the seams now known to exist in the Spring Hill basin proper. A considerable portion of the season was, therefore, devoted to the attempt to elucidate the structure both to the north and west, as also of the Spring Hill area itself.

General structure of the Joggins area.

The general structure of this portion of the country will now be given. Leaving the belt of Millstone-grit which underlies the productive measures at the Styles mine, and going down the brook which flows thence to Little Forks River, we find a series of sandstones and shales dipping southerly at angles of 30° to 40°. No coals have been recognized in this section other than that known as the Styles seam. Just before reaching the Little Forks River, grey sandstones dipping south-westerly $<$ 13° occur, which are supposed to mark the Upper Carboniferous, whose distribution has already been given.

Valley of Black River.

Between the Little Forks River and the ridges of Claremont and Spring Hill is the valley of the Black River. The Economy road, which connects the two places, passes over a ridge of greyish sandstone, very much of the character of the Millstone-grit; no ledges are seen on the road except at one point where it makes a sudden bend to avoid the spur of a hill. Here, in a quarry, the dip is generally S. 70° E. $<$ 12°-16°. This place is two miles and a half from the crossing of the Little Forks at Stewart's. Thence to the vicinity of Black River the soil is grey, coarse and gritty.

From the corner of the road north of Black River a road runs north-easterly to the old Economy road, which crossed that stream about three-

eighths of a mile above the Forks of the Chase Lake Brook. Along this road the soil is generally reddish, indicating a change of formation, and a prominent ridge or escarpment which keeps along the north side, marks the limit of the grey sandstone in this direction. Between the road and the Black River, as well as in the bed of that stream, red Lower Carboniferous sandstones and conglomerates, with large pebbles, occur, dipping S. 20° E. < 16°-20°. These extend up the Chase Lake Brook for fifteen chains, to ledges of grey sandstones, shales and conglomerates of Millstone-grit aspect, which are a portion of the ridge crossed by the road from Little Forks stream. They dip S. 50° E. < 15°-20°, and further up stream are associated with purple sandstones and shales, which dip also in the same direction at an angle of 20°. It was formerly supposed by Mr. McOuat that the grey and purple beds, just described, belonged to the Upper Carboniferous, and were the equivalents of the Ragged Reef sandstones, and that the Lower Carboniferous of Black River was brought into its present apparent position above the newer beds by a fault of great extent. The examination of the past season tends to confirm the opinion held by Mr. Scott Barlow, that the ridge under discussion is much older and is a true portion of the Millstone-grit formation.

Chase Lake Brook.

Millstone-grit ridge.

The presence of the Lower Carboniferous along the Black River and its vicinity, in a generally undisturbed condition, proves the thinness of the overlying formation. The lack of exposures on the road crossing the ridge prevents the conclusive evidence of its anticlinal structure in this direction being observed, but it seems probable from the overlying members of the Upper Carboniferous on Little Forks River, that a reverse dip occurs, and that the true structure of the ridge is that of a low anticlinal, capping the underlying Lower Carboniferous conglomerates. Evidences of this structure are apparent on the Intercolonial railway, about one mile east of Spring Hill junction, where a reverse dip to that noted in the quarry on the road s met with.

Anticlinal in Millstone-grit.

The various cuttings on the railway, between Salt Springs station and Spring Hill junction, also throw much light on the structure of this section of the country. West of the crossing of the South Branch of Black River, grey sandstones, shales and conglomerates, bearing a strong resemblance to Millstone-grit sediments, appear at intervals for three miles. They dip generally N. to N. 10° W. < 15°-20°. These represent the western prolongation of the ridge already described. A quarry is now worked in these sandstones about two miles west of the Black River crossing. About one mile and a half beyond the quarry hard grey quartzose sandstones, altered and slickensided, show in a cutting, dip west < 5°, though apparently much broken. The

Contact of Millstone-grit and Lower Carboniferous.

nearest exposure of the Milistone Grit sandstones is half a mile east, where they dip N. 10° E. < 20°–25°. These altered sandstones probably indicate the outcrop of the underlying Lower Carboniferous and the existence of a line of fault at this point, which is directly on the course of the main north and south fault of the Spring Hill mines, presently to be described. Thence west, at 1,440 paces, a small brook and culvert mark the lower end of Stewart's meadow. At this place ledges of soft red and greyish marly shales occur, associated with beds of gypsum. These extend for 1,100 paces to the top of the grade east of Spring Hill junction, plaster pits being numerous along the north side of the railroad at several points, and mark the presence of a Lower Carboniferous outlier, which may have been brought to the surface by the fault just indicated.

Probable fault.

Lower Carboniferous outlier.

It is probable that the outcrop of gypsum and shale at this place represents the beds of Black River and vicinity, the gypsiferous belt being recognized as far as the River Philip in the direct line of strike. Proceeding west from the summit of the grade the grey sandstones of the Millstone-grit are again seen, dipping N. 50° W. < 16°, indicating an anticlinal structure in this direction, and confirming the hypothesis that the measures comprising the ridge already described have no great thickness, and that the productive formation is probably, or at least in so far as can at present be ascertained, entirely wanting in this direction.

On the branch railroad to the Spring Hill mines and Parrsboro', no ledges are seen till we pass the East Brook, two miles and a half from the junction. The surface on both sides is frequently strewed with large blocks of coarse grey grit and conglomerate. Between the East Brook and the mines, at a distance of one mile from the east slope, a ridge of limestone holding Lower Carboniferous fossils comes to the track from the east. The intervening space to East Brook shews several cuttings in grey grits, with two thin seams of coal, one of which has a thickness of one foot four inches. The ridge of limestone referred to is the western terminus of the Lower Carboniferous area which extends thence continuously to River Philip, and flanks the high land of Claremont Hill, being connected also with the conglomerate and gypsum of Black River.

Lower Carboniferous limestone near Spring Hill mines.

The northern boundary of this Lower Carboniferous area runs in a nearly straight easterly direction from the terminus on the Spring Hill railroad, to the south branch of Black River, which it crosses near the head of Dixon's mill pond. Here evidences of a fault are clearly seen at the junction of a small stream from the west known as Deep Brook, the Lower Carboniferous conglomerates, sandstones and shales dipping N. 5° W. < 90°, while the succeeding beds dip N. 10° W. to N.

Fault.

$< 45°$. Thence eastward, the boundary of the Lower Carboniferous gradually curves to the north along the west flank of Claremont Hill, till it reaches the River Philip road about one mile and a half east of Salt Springs station.

Resting upon the Lower Carboniferous beds, at the mouth of Deep Brook, are ledges of grey sandstone and sandy shales. These, on the east side of Dixon's pond, are underlaid by coarse reddish grits and conglomerates, broken and slickensided, indicating the presence of a fault in this direction. The grey sandstone and shales resemble the lower members of the Middle Carboniferous, and contain an abundance of plants from which a collection was made by Mr. Scott Barlow, and examined by Sir Wm. Dawson, the results of which also tend to establish their horizon as that of the Millstone-grit. One hundred yards below the mill there is a seam of coal of excellent quality, one foot four inches thick, and three chains and a half further a second seam with a thickness of two feet six inches is seen. This was opened during the past season (1884), and a considerable quantity of coal extracted. The measures at this place dip N. 10° W. $< 40°$. Thence to the railroad, grey sandstone and shale occupy the stream.

Coal seam of South Branch of Black River.

The structure of the area just described is plainly a shallow synclinal, the reverse dips being seen to the north of the Intercolonial, and bounded on both margins by Lower Carboniferous sediments, of which that noted at Stewart's meadow is the northern outcrop. From the character of the sediments, and the contained fossils, it is doubtful if the true productive measures appear at all in this direction. That the thick seams of the Spring Hill basin are absent is quite manifest. The eastern extension of this synclinal is somewhat difficult to trace, owing to lack of good exposures, but from the outcrops of gypsum and other Lower Carboniferous sediments along the north side of Claremont Hill it appears to terminate about one mile and a half east of Salt Springs station, beyond which the Lower Carboniferous formation apparently occupies the surface between the River Philip road and Black River.

Synclinal structure.

The structure of the Spring Hill basin is exceedingly complicated, owing to the presence of several faults which have seriously affected the regularity of the measures. The eastern and southern limits have been carefully traced by the examination of all the available outcrops.

Beginning with the southern boundary, it may be generally stated that the contact of the Middle with the Lower Carboniferous is not far from the line of the Maccan River in its upper part. On the south side of this stream exposures of rocks of the lower formation are seen at intervals from the line of the railway from Spring Hill to Parrsborough, below Halfway Lake, forming a belt from a mile and a half to three miles in width, and resting upon the northern flank of the Cobequid range.

South side of Spring Hill area.

On the road from Maccan River to Five Islands these rocks are well exposed at an old mill about 250 yards south of the stream. They consist of red conglomerates and sandstone, dip N. 45° W. $<$ 20°.

Boundary of Spring Hill Basin.

South-east of Spring Hill mines their outcrop crosses the road to Windham Hill, near the house of the widow Tillot Smith, whence it extends east for 100 chains and sweeps gradually round to the north-west, terminating the Middle Carboniferous basin in this direction. The eastern boundary is somewhat sinuous. It crosses the south branch of Black River fifty chains north of the road from Spring Hill to Henry Smith's, whence it curves along the east side of the Spring Hill ridge and crosses the road leading from the mines to Salt Springs at forty chains west of the Black River crossing, beyond which it extends north-westerly to the outcrop of the limestone already described as occurring on the railway between the junction and Spring Hill mines.

Streams surveyed.

The principal streams which intersect this area and on which exposures are found are the East Branch of the Maccan River, along the southern border, Rattling, Harrison's, Coal Mine and East Brooks. But few ledges are seen on the roads. Both streams and roads were carefully chained by Messrs. Barlow and McOuat.

Section on Etter road and Rattling Brook by Mr. McOuat.

The Etter road, to which reference has been made by Mr. McOuat—(Report of Progress, 1873–74, p. 169)—extends from the Upper Maccan River road to the road leading from Spring Hill to Athol. Several outcrops are visible between the river road and the line of the Parrsborough railway. These consist of greenish-grey grit and sandstone, with thin beds of conglomerate, and are well exposed at a small quarry half a mile north of the fork of the road. They dip N. 35° W. $<$ 16° and are overlaid a little further on by large ledges of coarse conglomerate, conforming in dip with the underlying beds and containing pebbles of grey quartzite, white quartz, felsite and slates. Thence to Furlong's house, sandstones, grey and sometimes thin-bedded, occur, between which and the railroad no ledges are seen. The Rattling Brook, which runs north-westerly across the formation and crosses the Etter road a short distance north of the railway, affords us a very good section of the remaining members of the formation under discussion, and as the strata exposed in this stream are very similar to those noted on the other brooks to the east, the characters and descriptions of the rocks here observed may be applied to the other localities. The dips are uniformly regular and the section is given in ascending order from their most southerly outcrop and taken from the notes of the late Mr. W. McOuat:—

Grey and reddish-brown fine grained sandstones with arenaceous shales. N. 60° W. $<$ 25°

Grey sandstone.
Coarse greenish-grey sandstone, soft argillaceous sandstone, mottled red and grey.
Bluish-grey, overlaid by thin-bedded red sandstone.
Fine reddish-brown sandstone, with greyish bands. N. 60° W. $< 25°$.
Grey sandstone, mostly flaggy and coarse. N. 55° W. $< 43°$.
Reddish sandstone, mostly in thin beds, underlaid by red shales.
Grey sandstone, with fossil plants, underlaid by reddish, argillaceous sandstone.
Grey, moderately fine sandstone in thin beds, passing upward into red sandstone and shales. Dip N. 45° W. $< 25°$.
Measures concealed for forty chains.
Soft red argillaceous sandstone. N. 40° W. $< 15°$.
Coarse grey conglomerate, 40 feet thick, with thin bands of coarse grey grit in upper part.
Measures concealed for ten chains.
Coarse grey conglomerates and grey sandstone.
Measures concealed to railroad thirty-five chains.

The brownish-red sandstone and shales are similar to the purple beds described elsewhere as a portion of the Millstone-grit series.

The upper part of this section is seen on the East Brook below the Etter road and consists of

Coarse grey sandstone approaching a conglomerate in thin beds, inclining to brownish-grey shales at top. N. 28° W. $< 10°$.
Grey sandstone.
Coarse conglomerate and grit in large blocks.

The last exposures half a mile north of the railroad are red sandstone in even layers of half an inch to two inches thick. Dip N. 30° W. $< 5°–7°$.

Thence for one mile and a half along the road no exposures are seen to the crossing of Coal Mine Brook, where soft, brownish-red sandstones of Upper Carboniferous aspect are noted, dipping N. 65° W. $< 8°$.

Unconformity of Upper Carboniferous on Millstone-grit.

The stratigraphical relations of the rocks of the section just described, together with the character of the sediments, very conclusively establish their horizon as that of the Millstone-grit, and the unconformable superposition of the Upper Carboniferous at Coal Mine Brook tends to confirm this view, and, as on the Maccan River further west, shews that the true productive measures do not appear at the surface in this direction.

Harrison's Brook.

The Mountain road runs parallel to the Etter road three miles further east and about two miles west of the Spring Hill mines. No ledges are seen, except at the crossing of Harrison Brook, where purple shales and sandstones dip N. 65° W. $< 20°$. On this stream, however, exposures are quite numerous. The strata dip uniformly north-

westerly < 30°–50°, and are, undoubtedly, the continuation of those described on Rattling Brook, consisting of heavy beds of conglomerates and grits with red and purple sandstones and shales. Indications of faults are seen at several places. None of the productive measures are visible on this stream, though indications of coal in thin seams have been noted in its upper part.

The Spring Hill and Parrsborough railway, which traverses a large extent of the Carboniferous area under consideration, while shewing very few rock cuttings, gives us at two points very material assistance in the attempt to work out the structure of the Spring Hill basin, and enables us to determine with great exactness its northern and southern limits. The former is indicated by the ridge or outcrop of Lower Carboniferous limestone, already described, which approaches the railway one mile north of the east slope. The coal seams and associated strata as they approach this outcrop rapidly increase the angle of dip to 70° or more, and in the underground workings in this direction the coals are stated by the manager to be terminated abruptly against the limestone, the rocks near the contact being much confused, indicating a line of fault, the course of which at the northern extremity is found to be S. 28°–31° W. magnetic, or S. 6°–9° W. with reference to the true meridian. It is very evident that the Lower Carboniferous outlier ends the Spring Hill basin in this direction.

Fault in the northern portion of basin

The fault just mentioned is well seen at the surface on Mill's Brook, which flows across the measures midway between the east and west slopes. Descending this stream, limited outcrops of the strata of the productive measures, which overlie the thick seams of this area, are seen for 1,970 paces from the railroad crossing or to a point thirteen chains beyond where the stream turns west, where the strata which are hard grey sandstones and purple grey shales dip N. 82° W. < 60° to 85°, the underlying beds of the productive dipping W. < 30°. By this fault the beds of the Millstone-grit formation are apparently thrown upward and cut off the coal seams of this area. Thence down Mill's Brook the rocks are similar to those in the two brooks already described, consisting of coarse and fine grey conglomerates, the pebbles of which are white quartz, coarse and fine grey grits and sandstones, with purple sandstones and shale. They dip generally north-westerly, ranging from N. 60°–75° W. < 15°–30°, but in one place are nearly horizontal, or S. W. < 2°. Indications of faults are seen at several points.

Fault on Mill's Brook.

These rocks extend at least to the forks of this stream with East Brook, exposures being very rare in the last half mile, and below this to the Athol road few ledges are seen. Ascending the East Brook no ledges are observed, but a ridge of Millstone-grit sandstone and con-

East Brook.

glomerate extends between the two branches north-easterly to the line of the Spring Hill railroad.

Fault on the railway to Parrsborough.

On the railway to Parrsborough the limit of the Spring Hill coal basin to the south-west is clearly seen at a distance of 512 paces west of the crossing of Coal Mine Brook. At this point, ledges of hard grey sandstone, grit and conglomerate are brought up by a well defined fault against the productive measures. The older or overlying portion, at the line of contact, dip N. 70° W. < 85°–90°, the inclination decreasing in fifteen paces to N. 55° W. < 60°. The ridge caused by these hard grey rocks is seen to extend across the Athol road, beyond which it is concealed by the intervening forest.

Fault on Coal Mine Brook.

The line of this fault is also well seen in the Coal Mine Brook about seventeen chains below the railroad crossing, the hard sandstones dipping N. 55° W. < 45°. If we connect the several points thus indicated it will present a nearly straight line between the northern and southern extremities. It is presumed, therefore, that a line so drawn will determine approximately at least the western boundary of the Spring Hill coal field.

Descending the Coal Mine Brook, the rocks of the Millstone-grit, brought into view by the fault just described, are seen almost to the crossing of the Athol road. They consist of hard grey sandstone, grit and conglomerate, interstratified with beds of purple shale and sandstone. Abrupt changes of dip are seen at several points. At one of these, half a mile in a direct line from the railway crossing, heavy beds of red shales much polished and slickensided are brought into contact with grey gritty sandstones, the former dipping N. 20° W. < 75°–80°. The course of this break is apparently nearly east and west magnetic, or nearly along the course of the stream. Below this, brown shales dip N. 65° W < 25°, changing a little further down to N. 85° W. < 14°.

Millstone-grit, character of beds and overlap of Upper Carboniferous.

Succeeding these beds, heavy masses of coarse grey sandstone and conglomerate, the latter with white quartz pebbles and of Millstone-grit aspect, dip N. 40° W. < 15°–25° and continue to the last exposures on this stream. The great similarity of the rocks on all these brooks will be readily recognized, the heavy beds of grey conglomerate being a prominent feature, while the absence of any measures to the north and west of the faults just indicated, which may properly be said to belong to the productive formation, will be easily seen. It is supposed that the overlap of the Upper Carboniferous upon what is here regarded as the Millstone-grit is about half a mile west of the forks of East and Mill's Brooks.

Faults on south side of Spring Hill area.

Along the south side of the Spring Hill area two faults at least are visible. One of these was definitely located by Mr. Scott Barlow and

is laid down on his map of this area already published. This had the effect of throwing the coal seams to the eastward. A much more important one, however, must exist in close proximity, by which the measures are entirely cut off in this direction. Its exact position is not easy to determine, owing to the general covering of soil and drift, but in a small brook flowing into the South Branch of Black River, about two miles east of Miller's Corner, it is clearly seen. Here the Lower Carboniferous strata at the contact dip S. 10° E. $< 80°$, while the nearest beds of the Middle Carboniferous dip S. 30° W. $< 10°$. The western prolongation, if continuous, would carry it thirty-five chains south of Miller's Corner.

Character of measures between Spring Hill and the Maccan River.

It is probable, however, that other faults of greater or less extent may exist in this area. The abrupt change in the strike of the measures seen at the south slope as compared with that seen on the road to Rodney proves conclusively a great disturbance in the rocks of this locality. The Middle Carboniferous to the south and east is evidently quite distinct from that at the mines, and forms a shallow basin which terminates about one mile and a fourth east of the road at Thomas Boss's place. The beds in this area are nearly flat, dipping at angles of 2°–10°, and it is very evident from the synclinal structure of this portion and the general horizontality of the measures that no space exists for the extension of the Spring Hill seams in this direction. The small seam of dirty coal found to the east of the South Branch may possibly be the broken portion of one of the thin seams of the Millstone-grit, to which formation it is likely the shallow synclinal in this section belongs. To the east of the Spring Hill mines the underlying Millstone-grit formation comes in under the productive measures in its regular order, and overlies the Lower Carboniferous of the South Branch. It can also be recognized on the road leading to Salt Springs and on the south flank of the limestone ridge which terminates at the railway.

The structure of the Spring Hill basin, as here explained, will, if correct, have a very important bearing on the prospects of finding the extension of the great Spring Hill seams to the north and west. By the faults just described as bounding the area on the west and south, the lower or Millstone-grit portion of the Middle Carboniferous appears to be thrown upward several thousand feet, and the coal seams have doubtless been subsequently removed by denudation. To the north and west the productive measures do not, as already stated, again appear at the surface, the Upper Carboniferous in all observed contacts apparently resting on the Millstone-grit.

No indication of the Spring Hill seams towards Athol.

It would be rash to say that the thick seams of the Spring Hill coal field may not be found in the area between the mines and Athol, but no indications, pointing in that direction, are to be observed.

The country lying to the west and north of the Millstone-grit upthrow is occupied by what is apparently the eastern prolongation of the great Joggins basin, the seams of which, with the exception of those of the Joggins mine and its extension eastward, are all, in so far as can be learned, too thin to be economically valuable. From the remarks already made on the character of the area in the valley of the Black and Little Forks Rivers to the north, it is evident also that a repetition of the Spring Hill basin can not reasonably be looked for in this direction.

Millstone-grit area of River Philip. Eastward of Spring Hill on the River Philip, a detached basin of Middle Carboniferous sediments is seen, the western boundary of which is the ridge of Claremont Hill. The strata, which contain one or two thin seams of dirty coal, belong, without doubt, to the Millstone-grit portion of the formation, and rest upon Lower Carboniferous rocks on all sides. Outcrops of coal are seen at two points, one on Polly Brook, a short distance from its junction with the River Philip; the second about half a mile east of Oxford station on the Intercolonial railway. **Coal near Oxford station.** At the latter place two thin seams are seen, separated by about four and a half feet of grey shale. The thickness of the upper seam was about fifteen inches, and of the lower two feet and a half, but the coal seemed dirty. The dip of the strata in the opening was S. 30° E. $<$ 15°-20°.

Areas south of Cobequid Mountains. On the south side of the Cobequid Mountains the areas of the Middle Carboniferous are apparently very limited. They are, in so far as observed, confined to the lower or Millstone-grit portion, and occur as small patches at intervals along the shore of Minas Basin and Channel, between Five Islands and Advocate.

LOWER CARBONIFEROUS. G. 1.

By reference to the Report of Progress, 1876-77, it will be seen that this formation, as developed in Albert and Westmoreland counties, is divided into five groups. These in ascending order are:—

Divisions recognized in New Brunswick

	FEET.
1. Basal conglomerate, sometimes wanting; when present, usually of a dull greenish colour, made up mostly of slate fragments; thickness, presumably about	200
2. Calcareo-bituminous shales, from grey to dark brown in color, including the so-called Albert shales..................	850
3. Grey bituminous and micaceous oil-bearing sandstone, and lower conglomerates, in massive beds, usually of reddish tint, less rubbly and more calcareous than those of No. 1, and unconformable to the preceding.................	700
4. Red and grey calcareous, sandy and argillaceous beds, in frequent alternations, with thin beds of conglomerate, and towards the top, heavy beds of fine rubbly brownish-red shales	450
5. Red and grey conglomerates, grey and flaggy limestones and gypsum...	1,950

In the last division a small thickness of not more than 50-75 feet of red marly shales lies above the gypsum.

Increased thickness of No. 5.

These measurements were made in the vicinity of the Albert mines, and at various points between Baltimore and the Petitcodiac River. The sections seen on the west side of the Maringouin Peninsula will change the character of No. 5 by adding over 2000 feet to the red marly shales which come above the gypsum and underlie the Millstone-grit series of Cape Maringouin, the details of which will be given later.

The distribution of the Lower Carboniferous in central Albert county and the portion of Westmoreland, west of the Memramcook River, is stated in detail in the Report of Progress, 1876–7. It will not be necessary, therefore, to give any further description of that area, but to limit our remarks to its distribution along the southern coast, from Cape Enragé eastward.

Areas of Lower Carboniferous in southern Albert county.

On the road leading from Harvey Corner to Cape Enragé, reddish sandstone and red and grey marly shales are seen in a brook at an old mill 500 yards in rear of James Reid's house in New Horton. They dip S. 65° E. $<$ 35°. These underlie the Millstone-grit which occupy the point south of Harvey Corner. Thence they extend along the road west to a point in rear of Two Rivers Cove, where they are overlaid by the Millstone-grit of the coast already described.

On the west side of the Cove beyond Cape Enragé lighthouse, hard sandstones, mostly grey, considerably broken up, and with indications of faulting, dip S. 70° E. $<$ 70°. They contain small veins of limonite from half an inch to an inch thick. Around the point, the rocks are a good deal disturbed, hematite occurring along the joints, but north of this, red and grey sandstones and shales, with conglomerates, occupy the shore for seventy chains across the strike. The angle and direction of the dip continuing constant, the estimated thickness of the measures here exposed would be about 4,500 feet. At the contact with the Millstone-grit on the north side there is probably a line of fault, the first exposures of the latter dipping N. 65° W. $<$ 80°.

North of the second parallel ridge of Millstone-grit already described a second area of Lower Carboniferous rocks occurs, which comes to the coast of Salisbury Bay at Owl's Head, and thence extends easterly along the valley of the Germantown Lake and Shepody River, and terminates on the Petitcodiac River at Demoiselle Cape. It includes the elevation of Shepody Mountain in its eastern portion. The first outcrops are noted on the road from Hopewell Corner to Salmon River, about midway between Crooked Creek and the shore of Salisbury Bay, the Lower Carboniferous beds dipping S. 65° E. $<$ 20°, and resting upon the Millstone-grit formation, indicating a probable line of fault at this place. In the Germantown and Shepody area, exposures are few, but

the character and color of the soil indicate the extension of the formation in this direction. East of Hopewell, a good section is afforded on Saw Mill Creek, which crosses the road half a mile west of Hopewell Hill. On this stream, two miles and a half north of the P. O., Lower Carboniferous conglomerates rest upon the upturned slates of the Caledonia Mountain, and dip S. 20° E. < 5°–10°. They are well exposed to the junction of the Middle Branch, sixty chains below, where a reverse dip to N. 50° W. < 5° in flaggy brown sandstone is observed, below which the dip gradually changes to N. 20° W. < 20°, indicating the presence of a shallow synclinal. Gypsum occurs at several places in this vicinity, the most westerly being on the banks of the Shepody River, near Riverside. Gypsum.

Shepody Mountain, 1,050 feet high, is a rugged peak which forms a prominent landmark for many miles in all directions, and was one of the signal stations for the Admiralty survey of the Bay of Fundy. It is composed largely of red conglomerates, which are well exposed on the east flank in Robertson's Brook and its branches. A deposit of reddish impure limestone has been opened up at this place for a marble quarry, but the rock was found to be too much shattered to be of great value. The limestone contains a small quantity of manganese. The rocks of the mountain rest upon a small outlier of the talco-chloritic schists, which shew on the road to the north, leading to Curryville, and are flanked on the east by the grey sandstones of the Millstone-grit. On the north-west side, a large deposit of manganese was worked for some years, a tunnel being driven into the mountain along the contact with the underlying schists for nearly 1,000 feet. The ore, which consisted of pyrolusite and psilomelane, occurred at the base of the conglomerate in irregular pockets. Operations have been suspended for some years and the workings have all fallen in. At the mouth of the slope the conglomerates dip N. 15° E. < 15°–20°. Shepody Mountain. Manganese.

Along the valley of the Demoiselle Creek, between Curryville and the Albert mines, Lower Carboniferous sediments are also found. On the east, between the creek and Petitcodiac River, they are covered by the overlying ridge of Millstone-grit, but on the streams flowing in from the west, they occupy a considerable extent, forming the prolongation of the area of the Albert mines. The rocks are principally red and grey marly shales and sandstones, but on Wilson's Brook large ledges and cliffs of gypsum from 80 to 100 feet high are seen. A fine quarry of reddish grey limestone was opened in the vicinity some years ago by Mr. McHenry, and a large quantity of lime of excellent quality has been burned. Limestone.

On the west side of Cape Maringouin Peninsula red marly shales and sandstones of the Lower Carboniferous are in unconformable con-

tact with the Millstone-grit, which forms the extremity of the peninsula for half a mile. The Lower formation extends along the shore, obliquely to the line of strike, for sixty-five, or directly across the measures for twenty-seven, chains. The following section was made :—

Section on Maringouin Peninsula.

	FEET.
Red marly shales and sandstones, the latter often greyish but distinct in character from the Millstone-grit	1518
Measures concealed, red clay, probably the same	729
Reddish and grey fossiliferous limestone	130
Gypsum, with red and grey marls, much twisted, and actual thickness very uncertain—Exposed breadth	500
Thence, measures concealed to small brook, on which gypsum again appears, along the beach, for	1188
Measures concealed, thickness unknown	2112
Red marly shales, S. 5° E. < 85°-90°, to axis of anticlinal	264
Red marly shales, vertical, to contact with overlying Millstone-grit	1650

Further north, one mile above Johnston's Creek, similar red marly shales crop out on the shore, dipping N. 5° E. < 35°. They are exposed for nearly half a mile and represent, in this place, a thickness of 1,150 feet. Still further north, at the creek below Dorchester Cape, red marls and dark red conglomerates with beds of sandstone are again seen, dip N. 15° E. < 30°. They are exposed for seventy-five chains, and, measured directly across the strike, have a thickness of 1,250 feet. No gypsum is seen in this direction.

East of the Memramcook River, between Dorchester and Calhoun's mill, the denudation of the horizontal beds of Millstone-grit has disclosed the underlying Lower Carboniferous measures, and produced a very irregular and sinuous outline. The distribution of the Albert shales which form a conspicuous feature in this area, and other members of the formation, has already been given in the Report of Progress, 1876–77, pages 371 and 378.

On the east side of the Maringouin Peninsula, the Lower Carboniferous rocks are exposed on the north side of North Joggins Cove, underlying the Millstone-grit. The measures are the same as those described on the west side, with the exception of the limestone and gypsum. They dip S. 5° E. < 40°, changing at Peck's Point to S. 20° E. < 40°. Plant beds are numerous at several places, and where found often disclose traces of copper which are, economically, unimportant. From Peck's Point the measures strike directly across Cumberland Bay to Boss' Cove, on the south side of which the contact between the two formations is seen.

Copper.

North of the creek above Peck's Point, and thence up to Harvey's Creek, the Lower Carboniferous beds dip N. 30° W. < 75°–80°, indicat-

ing the presence of an anticlinal, which is the extension of that noted in the section on the west side. A short distance north of Upper Rockland P. O., they are overlaid by Millstone-grit sediments already described.

On the north side of Peck's Point, near the upper limit of the exposures, a bed of very fine grained red sandstone of peculiar texture is found. It has been quarried to some extent and shipped in all directions for grinding and polishing marble, for which purpose it is peculiarly adapted, and commands a high price in the market. The merits of this stone were first pointed out by Mr. H. J. McGrath, marble cutter of Dorchester. Since 1876, in which year the report on the Lower Carboniferous belt was written, extensive explorations, more especially in the group of the Albert shales, have been carried on, involving the expenditure of large sums of money in the search for albertite and petroleum. The celebrated Albert mine became entirely exhausted at a depth of a little over 1,500 feet, the vein gradually thinning out as traced downward. Explorations were made in various directions by the Albert Mining Company in the vicinity, but no other veins of workable size were found, and the mine has accordingly been dismantled and allowed to fill with water.

Sandstone for finishing marble.

Albert mine.

The explorations on the adjoining or Princess Alexandra area, where borings were made to a depth of over 1,100 feet, were alike unsuccessful in finding any vein of economic importance. In the western part of the county, at Elgin, where the shales are also well developed, several bore holes were put down, but without meeting with albertite in any quantity. East of the Petitcodiac River, on the Beliveau Mining Company's property, both at Beliveau and Taylor village, extensive explorations were carried on for some years. At the former place a shaft was sunk to a depth of 500 feet, and tunnels driven in different directions, involving an outlay of over $40,000. In the latter, the operations were carried on with a diamond drill, several holes being put down. In both places only small veins were found.

Princess Alexandra mine.

Beliveau mine.

Boring operations have been carried on for years, both in the vicinity of the Petitcodiac River, near Dover, and in rear of St. Joseph's college at Memramcook, in the hope of finding petroleum. A small quantity of oil is reported in several of the holes, but the amount so far found has been insignificant.

Petroleum.

In Cumberland county the extension of the Lower Carboniferous anticlinal, seen on the southern part of Cape Maringouin, after crossing Cumberland Bay, reaches the Joggins shore, as stated, at Boss' Cove, and is thence exposed northward along the beach, to a point half a mile beyond Downing's Cove, with a breadth of two miles and a half. There it is overlapped by the Upper Carboniferous of the Amherst basin,

Extension in Cumberland county.

whence it extends eastward, crossing the Maccan River and forming an unbroken belt to the extremity of Cape Malagash, on the north side of Tatamagouche Bay. This ridge forms the north side of the Joggins or Cumberland Coal basin.

Southern side of Lower Carboniferous.

A second belt of Lower Carboniferous rocks which forms the southern side of the basin is found on the shore at Chignecto Bay, at Spicer's Cove, seven miles north of the end of Cape Chignecto. Where it comes to the coast it has an exposure of about 500 yards, but inland it rapidly spreads out, including the village of Eatonville, and with a breadth of from two to four miles, keeps along the north flank of the Cobequid range nearly to its eastern extremity.

East of the Spring Hill mines these two areas are joined by the elevations known as the Windham and Claremont Hills, the overlying Middle and Upper Carboniferous sediments being thus separated into two distinct basins.

Character of the formation in the Joggins section.

The rocks of the coast sections north of the Joggins are reddish shale with greenish and red sandstone, grey shales, grey compact limestone and gypsum, with heavy beds of marine limestone in their lower part, containing characteristic Lower Carboniferous fossils.

Throughout the northern belt, gypsum and limestone are very abundant, and are exposed at intervals from Minudie to Malagash. This area probably represents the upper members of the series given at the beginning of this section. The strata of the Joggins' shore are similar in many respects to those of Maringouin, and the same character of rock is maintained with considerable uniformity throughout to its eastern extremity.

Along the southern belt the gypsum seems to be wanting or very rare. The rocks are largely grey and red conglomerates, often coarse and hard, with bands of sandstone and shale. They possibly represent divison 3 of the New Brunswick series.

From the preceding description of the upper and middle formations, the outlines of the Lower Carboniferous have been generally given, at least for the region west of Spring Hill. They occupy the greater part of the valley of the south branch of Black River and the ridges known as Claremont and Windham, whence crossing the River Philip road the area is apparently unbroken almost to the mouth of the River Philip.

River Philip.

The section on this stream is not continuous. Limestone and gypsum are first seen about three-fourths of a mile below the Intercolonial railway crossing, and the country in the vicinity to the east and west is occupied largely with these rocks. Though exposures are rare, the strata on this stream seem to lie in the form of two anticlinals, the axis of one being seen at Goose Point, about midway between Oxford and the mouth, while the axis of the other is probably not far from

the vicinity of Oxford itself, the exact position being concealed by the thick mantle of drift.

Pugwash River.

The Pugwash River further east also shews but few exposures. At the crossing of Grey's road, three miles north of Thompson station, large outcrops of gypsum occur, which extend down the stream for several hundred yards. These mark the southern limit of the southerly anticlinal in this direction. Exposures below this on the stream and roads are very few, but from the character of the soil and the loose pieces, it is probable that this formation extends continuously to the lower part of Pugwash Basin, as limestone and gypsum are well developed in that locality both to the east and west.

Wallace River

The Wallace River, the next stream to the east, affords a fine section of the rocks of this formation, underlying the Upper Carboniferous basin already described. On the north flank of the Cobequid Mountains at Wentworth, brownish and grey sandstones and shales rest upon the Silurian strata of Whetstone Brook. They dip N. 5° W. $<$ 30°–45°, the underlying Silurian at the contact dipping S. 20° E. $<$ 40°. The sandstones are also well exposed at an old quarry on Caldwell's Mill Brook, just beyond the end of the road leading down the mountain from Wentworth station.

Thence down the Wallace River for several miles exposures are few. Where seen they consist of red conglomerates, often coarse, dip N. 10° E. $<$ 10°. These also show on the roads down the east side of the river, and they extend northward to the vicinity of the road leading to Swallow Settlement, where they are overlapped by the Upper Carboniferous.

The finest exposures of the lower formation are about eight miles north of the road to Wentworth station and five miles from the mouth of the river. Here a continuous section for over three miles is exposed, the beds being inclined at a high angle, generally from 60° to 80°, and the dip very uniform in direction for two miles and a half. The section is a descending one, the beds being unconformably overlaid by the soft red sandstones of the Upper Carboniferous, and is as follows :—

Section in Wallace River.

	FEET.
Red sandstone and shales, S. $<$ 40°	330
Hard, dark reddish grits and fine conglomerates to head of pond, S. 20° E. $<$ 40°	200
Coarse grits with fine red shales and red conglomerate bands, the pebbles often coated with red hematite and polished or slickensided, S. 40° E. $<$ 45°	150
Coarse grits and conglomerates in alternate beds, the latter with pebbles of grey quartzite, felsite, granite, etc., coated with hematite and with a bed of greyish-white marly clay, 3 to 4 feet thick	200

Conglomerate and sandstone often hard and greyish..........	385
Hard grey conglomerate with thin bands of sandstone, S. 40° E. < 70°..	76
Coarse brown-grey irony conglomerates, with large polished pebbles, slickensided, greenish-grey conglomerates and grits, the latter with plant stems, greenish-grey and brown shales, with grits and conglomerates..........	660

It is possible that in this portion of the section some of the conglomerate beds have been repeated by faulting—

	FEET.
Brown and purple-tinged sandy shales, with conglomerates and grits in the upper part, S. 30° E. < 75°-80°............	860
Greyish and brownish-grey sandy shales and sandstones with plant stems, S. 20° E. < 75°-80°......................	1600
Brown and grey sandstones and shales, in thin beds, S. 40° E. < 70°..	210
Soft brown shales and grey hard sandstones, S. 40° E. < 50°-70° to foot of pond and Howard's mill....................	350
Brown and grey shales, with beds of hard sandstone, S. 20° E. < 80°..	360
Brown and grey shales, with nodular limestones and sandy and calcareous conglomerates, calcareous and sandy shales, red brown and blackish-grey..........................	810
Fault. Probable fault—reported silver mine.	
Red grits and conglomerates, with a bed of limestone four feet thick, S. 20° E. < 60..................................	640
Brownish shales and sandstones, measures concealed the greater part of the distance, S. 20° E. < 70°..................	2430
Brown shales and sandstones, with occasional band of hard grey sandstone, S. 20° E. < 80°-90°..........................	3730
To axis of anticlinal at Kerr's mill.	

Then for a further distance of 1000 paces down the stream, the beds above described are repeated with northerly dips at angles of 70° to 80°, when they are again overlapped by Upper Carboniferous sediments which form the shore area.

The exposed breadth of these rocks from their first outcrop in the River to the anticlinal is 210 chains. This, at an average dip of 70°, would give a total thickness of 13,000 feet. As this thickness would be entirely unprecedented for the Lower Carboniferous formation, we can only suppose that the various members are in places repeated. Unfortunately there is no continuous section of these rocks, either to the east or west, to compare with that just given. But on the shore of Malagash Point, a partial section throws some light upon the structure of this belt.

The anticlinal seen at Kerr's mill, on the Wallace River, comes to
Main anticlinal the shore in a small cove near the extremity of Malagash Point, the

axis itself being concealed in a salt marsh, the strata on either side of of which dip, respectively, N. 10° W. $< 74^\circ$, and S. 10° E. $< 65^\circ$. It also appears on the shore in a depression on the north side of the point, about midway between the end and the entrance of Wallace Harbor, the opposing dips being well seen. On the north side of the anticlinal, the portion corresponding with that to the north of Kerr's mill, shews the presence of several faults. Gypsum occurs at several places on this portion of the coast as well as about Plaster Cove, just inside the entrance of Wallace Harbor.

Gypsum.

Brownish-red and grey micaceous sandstones and shales, apparently in small outlying patches, rest upon the gypsum and other Lower Carboniferous rocks of this area. These are unconformable and probably are limited exposures of the Upper Carboniferous. Their inclination is generally low, from 16° to 18°.

Malagash Point

Copper.

As on the Wallace River the Lower Carboniferous sediments of Malagash Point consist of dark greyish-brown sandstone and shale, with interstratified beds of moderately coarse grey grits and grey limestone. These contain traces of copper at several places near the extremity, in every observed case in association with plant stems, as on the French River and elsewhere.

Probable thickness in Wallace River.

In the Wallace River section, the upper portion, to the bridge below E. Howard's mill, at several points shews slight local changes in dip, but just in the vicinity of the bridge a more extensive line of fault probably exists, by which the measures, seen on the lower part of the stream, are repeated, a general similarity between the members of the two sections being apparent. On this hypothesis, the beds on the lower end of the section from Howard's mill to Kerr's mill would have an aggregate thickness of about 6,800 feet, while the thickness of the portion lying to the south of the bridge would be 6,200 feet.

In the upper part of the lower portion, a band of limestone four feet thick occurs with red conglomerate. No limestone is found in the upper portion, but further east, in Dewar's River, near the head of Tatamagouche Bay, a similar band of limestone is seen, having the same thickness. This marks the southern limit of the Lower Carboniferous in this direction, and if extended west, should cross the Wallace River a short distance south of the beginning of the outcrop of the Lower Carboniferous on that stream, thus rendering the parallelism of the two sections more complete. It may be added that the section on this river was made by pacing only, and the thickness of the various members is, therefore, merely approximate.

East of Wallace River, along the flank of the Cobequid Mountains, the Lower Carboniferous belt quickly narrows, being overlapped by the beds of the Upper formation already described. On the road to

New Annan but one small exposure was observed, in a quarry on a small branch of Higgins' Brook, nearly four miles east of Wallace road. The dip was Northerly < 35°. On the East Branch of French River a small band of red-brown conglomerate, 200 paces north of the New Annan road, dips N. 10° W. < 20°, having a breadth of only 75 paces, which is probably the extension of this formation in this direction. East of this we have not traced it.

East of Spring Hill no strata of the true productive measures were recognized. The Lower Carboniferous has an extensive development occupying the entire surface, with the exception of the small areas of Millstone-grit already described, and the western prolongation of the Upper Carboniferous basin of the Wallace River, from the foot of the mountain range almost to the mouth of the River Philip. The productive measures, if deposited in this area, must be concealed by the overlapping Upper Carboniferous formation.

The more northerly anticlinal at Goose Point, on the River Philip, after crossing the Pugwash River near the basin, is apparently also concealed by the upper beds, a short distance to the east of that place, as it does not, in so far as can be ascertained, appear on the shore beyond; the whole coast, from the head of Bay Verte to Wallace Bay, being apparently occupied by the beds of the Upper Carboniferous.

On the line of the Intercolonial railway, between Thompson station and Wentworth, several cuttings are observed. These are apparently all in rocks of Lower Carboniferous age, red conglomerate and red and grey sandstones. On the east branch of the Wallace River these are, to the north of Greenville, also overlaid, unconformably, by the soft red beds of the upper formation.

Exposure on Intercolonial railway.

On the south side of the Cobequid range, the Lower Carboniferous formation has a considerable development and apparently extends in a continuous belt from the coast west of Advocate Harbor eastward to the North River, in the vicinity of Truro, where our examinations in this direction terminated. Sections were made across the measures on a number of the streams between the North River and Five Islands, including the Chiganois, the Debert, Pine Brook, Folly, Great Village, and Economy Rivers. The rocks on all shew considerable disturbance, frequent and abrupt changes of dip indicating the presence of faults of greater or less extent. A thin seam of coal is seen at several places in their lower portion, generally not far from the contact with the older series along the flank of the mountains and has been opened at several points from Kemptown on the Pictou road to the Folly River. The character of the coal seam at all the places where tested appears to be much the same, and it is apparently of but little economic value.

Development.

Distribution south of the Cobequid Mountains.

Coal.

The structure of the formation on the Debert River, of which a care-

ful micrometer survey was made from the mouth to within four miles of its source, is evidently a double synclinal, and as the character of the strata varies but slightly on the several streams, the description of the rocks here seen may be given as fairly illustrative of the whole.

The first exposure of Lower Carboniferous strata is seen in a limited outcrop near the mouth, at the crossing of the river by the road leading from Truro to Economy. Here at 100 paces below the upper of the two bridges, ledges of hard, bright red sandstone, strongly resembling in color the sandstone of the Triassic, come up abruptly from beneath the soft sandstones of that formation, the strata of which thence occupy the stream upward to the Intercolonial railway. Their dip at this point is N. 5° W $<$ 60°, and they are associated with red, grey and purple marly shales of Lower Carboniferous aspect. A band of impure gypsum is also noted on the lower of the two roads at this locality. Section on Debert River.

On the east side of the river these shales and sandstones dip S. 5° E. $<$ 60°, thus indicating the presence of an anticlinal at this place. Twenty-five chains below the lower bridge, on the west bank of the stream, beds of greyish and buff-colored limestone, overlaid by a bed of fibrous gypsum about four feet thick form the upper part of a cliff. They dip N. 20° W. $<$ 40°. The red sandstones extend from this place westerly to the Folly Village, where, on the south side of the Folly River, they are well exposed for some distance and have a high northerly dip, the reverse dip of the anticlinal being seen a little lower on the stream and the formation is overlapped by the soft beds of the Trias. West of the Folly River the Lower Carboniferous beds of this area do not appear. The outlier has an exposed length of a mile and a quarter and a general breadth of forty to forty-five chains.

The Triassic sediments which occupy the Debert River from this outcrop to a point one mile north of McCulloch's Corner have a general dip S. 10° W. $<$ 4°–7°. At the point indicated, bright red, hard and coherent sandstones and marly shales, identical in character with those just described, appear from beneath, with a southerly dip and shewing the presence of a synclinal basin in the intervening space. These are exposed for 240 yards and are underlaid unconformably by hard grey jointed sandstone or quartzite, which has a breadth of forty-five yards and rests upon black carbonaceous shales. These latter are apparently identical in character with a band which is associated with or accompanies the iron ore deposits presently to be described, and which has been traced continuously along the south flank of the Cobequid range for over sixty miles.

The black shales at this point have been opened, apparently in a vain search for coal, and, to all appearances, form one series with the Black shale.

quartzite. Though much broken up they appear to dip generally S. 40° E. < 60°. A little above, the shales become grey and are ochreous in places from the presence of a small quantity of iron ore. Quartzite. Indistinct traces of plant stems also occur.

The hard and quartzose sandstones are exposed for about fifty feet. Then, for 200 yards, the measures are concealed, to ledges of grey shales which, though somewhat broken, have a general dip S. 10° E. < 35°. These also contain plant stems and have nodules of clay ironstone. In character they are very like the grey sandy shales seen on the Pictou railway east of Riversdale station.

Twenty-seven paces up stream, the grey shales are unconformably overlaid by dark-brown, irony-looking conglomerates, and reddish-brown shales, which dip N. 30° W. < 65°- These are much slickensided and contain large quantities of red hematite, the conglomerates resembling very closely those of the Wallace River section already described. An anticlinal structure is very apparent in the underlying strata at this place.

The conglomerates are succeeded or overlaid further up stream by brownish or indian-red sandstones, with occasional bands of red conglomerate, which dip N. 10° W. < 70°. Occasional patches are grey and shew remains of plants, among which pieces of a calamite were noted. These extend for 220 yards. Thence for 450 yards the strata are brownish-grey sandstones, hard and quartzose, with grey grits and thin bands of brownish-grey shales, the dip remaining the same. At 180 yards further, dark-brown sandstones and shales, with remains of plants, dip N. 25° E. < 50, and are exposed for 270 yards. Thence for 800 feet further the measures are concealed to brownish and grey shales and sandstones, the shales sandy and slickensided in places, in others very fine grained, brown and marly, dip N. < 75°-90°, to line of fault. This is fifty chains in a direct line from the anticlinal mentioned above.

Thence measures are concealed for 500 yards, after which brown sandy and marly shales, changing to sandstones in 100 paces, occur and dip S. 10° E. < 20°. The angle of dip increases to 30° in 100 paces more, but in a couple of hundred yards is reduced to an angle of 5°. A little above, the dip is reversed to N. 10° W. < 5°, denoting a low anticlinal. 700 yards above, the dip is again reversed to S. 35° E. < 30°, the rocks being brownish sandstone and brownish-grey shales.

The strata, all along this portion, it will be observed, are very similar in character and have a decided Lower Carboniferous aspect. At the last noted exposure, the sandy portions are greyish and the shales marly.

A few yards above, grey sandstones and shales come in on the west bank of the stream, dipping N. 35° W. < 30°, indicating another anti-

clinal at this point. They here contain a seam of coal which is underlaid by grey clay, and where exposed in a slope on the west bank showed a thickness of 12 to 14 inches, associated with black and grey shales. The coal was apparently dirty and of little value. Coal seam.

In the vicinity, or a little below, several openings had been made and shafts sunk for a short distance. These, though filled with water, showed small quantities of coal and black shales at the surface, and were, in so far as could be ascertained, sunk on the same seam but on the southern side of the anticlinal. No other seam could be observed, either at the surface or in the bed of the river. This place is ten chains below the back road leading to Cotnam settlement, and no ledges appear on the stream between the coal opening and the bridge.

Above the bridge, the measures are concealed for nearly 200 yards. Then ledges of grey sandstone and marly shale are exposed in a small outcrop dipping S. 30° W. $<$ 30°. Measures are again concealed for half a mile to ledges of red and greyish-brown conglomerate with thin bands of sandstone. The conglomerate contains pebbles of slate, quartzite, felsite, syenite, &c., and dips S. 20° E. $<$ 35°, underlaid by others, which are coarse and irony, and like that noted at the anticlinal near the beginning of the section. These are in turn underlaid by greyish-brown coarse grit, and fine brown shales, dark red-brown conglomerates and thin bands of red sandstone, dipping S. 45° E. $<$ 45° to black carbonaceous shales, dip S. 30° E. $<$ 90°, like those first noted on the lower part of the stream, which complete the section. They are much broken and become grey in their lower part, and are exposed at intervals for thirty chains, having midway an outcrop of hard, greenish-grey rock, mottled with dark shades and containing a small quantity of calcite. This is probably a fine-grained diorite. The slates in this lower portion are graphitic, and dip S. 5° E. $<$ 40°. Greenish-grey and purple altered slates and quartzite containing limonite and spathic iron ores directly underlie the black slates, and are apparently conformable, dipping S. 5° E. $<$ 40°. These are the eastern extension of the iron-ore belt of the Londonderry mines. Iron ores.

Throughout this section no rocks which could be recognized as belonging to the Middle Carboniferous were seen, the strata throughout have a marked Lower Carboniferous aspect, and the coal seam, instead of belonging to the productive measures, is much more likely to be one of the thin coals, found in the lower formation at intervals along the north side of the Basin of Minas.

On the Pine Brook, a branch of the Debert River, a similar synclinal structure is found on the portion of the stream to the south of the road from the Cotnam settlement to the East mines, and about one mile and a half west of the section just given. The strata are brown Pine Brook.

and brownish-grey sandstone and shale of Lower Carboniferous aspect, resembling those on the Debert, but the measures are much less disturbed; the dips on the south side of the synclinal on the Pine Brook are generally N. 5°–10° W. < 30°–50°, and the exposed breadth of the formation from the contact of the Trias to the centre of the synclinal is eighty chains. The dips on the northern side, which apparently extend to the band of black carbonaceous shales near the foot of the mountain, are S. to S. 30° W. < 35°–50°. No traces of coal are visible on this stream.

Chiganois River.

To the east, on the Chiganois and North Rivers, paced sections were made. On the former stream, Triassic sandstones extend for one mile north of Belmont Corner, and have a low southerly dip. They rest unconformably upon brown and brownish-grey shales and sandstones of Lower Carboniferous age, which dip N. 10° W. < 35°. These are overlaid by red sandstones and conglomerates, which are like those seen on the Debert, and which are probably their equivalents. They dip N. 60° W. < 30°, gradually changing to west, the angle decreasing to 15°, and are exposed for sixty chains, when they are unconformably underlaid by grey and brown sandy shales containing remains of plants. These are much shattered, but in one place dip N. < 85°–90°.

Coal seam.

Similar beds, with occasional bands of grey sandstone and shale, extend up stream with a uniform dip of N. to N. 20° E. < 50°–60° for ninety-five chains. At this point a small shaft was sunk some years ago in a bed of grey sandstone and blackish coaly shale, which dip N. 15° W. < 50°. Small pieces of coal were strewed about the mouth of the shaft, and a thin seam of dirty coal occurs at this place. Above this, for sixty-five chains in a straight course along the stream, this dip is pretty uniform. A reverse dip is then seen to S. 35° E. < 60°, indicating the presence of a synclinal which is, doubtless, the extension of that already described on the Debert River and Pine Brook. The character of the sediments is also very similar, being mostly brownish-grey sandstone, shales and conglomerates. Above this to the mill, at the end of the road from Delany Settlement, the strata are more disturbed, frequent and abrupt changes of dip being noted. The rocks, however, continue similar in character, with perhaps a greater thickness of grey beds. A short distance below the mill, and for 150 yards above, hard, green and grey conglomerates occur, dip S. 40° E. < 30, associated with hard and fine grained sandstones and shales,

Fossil plants.

and with interstratified beds of black shale, which contain abundance of remains of plants in some of the layers. These, while presenting some of the features of Millstone-grit plants, are from their stratigraphical position without doubt older and probably indicate a portion of the Lower Carboniferous formation. A shaft has been sunk in a bed of

black shale just above the mill at this place in the search for coal, but without discovering any. Black shale.

This shale lies between thick beds of hard green conglomerates of Lower Carboniferous aspect, which rest upon greenish-grey and purple quartzite, containing spathic iron, the representatives of the iron ore belt in this direction.

The green conglomerates can be traced eastward through the Delany Settlement and across the road leading from Onslow to Judge Monro's house. Between this point and McCallum's mill, on the south branch of the North River, a small seam of coal occurs, which was opened many years ago, but found to be of no economic value. This is, probably, the extension of the seam seen at the Debert River. Coal.

The section on the west branch of the North River reveals strata similar to those already described. A well defined anticlinal is seen sixty chains north of the upper bridge, eight miles from Truro, between which and the iron ore belt, near McCallum's mill, the structure is a synclinal. The Lower Carboniferous, as exposed lower down on the stream is a good deal disturbed. Westward, on the Folly River and on the Intercolonial railway, north from Londonderry station, good sections of this formation are afforded. The synclinal structure already noted is evident at both places. On the Folly River, the contact with the overlying Triassic beds is near a small brook from the east, 500 yards above the railway viaduct. The first exposures are red sandstone and conglomerate, like those of the Debert outlier, which dip S. 10°–30° W. $<$ 50°, the upper measures being nearly horizontal or dipping southerly at a low angle. Underlying these red beds, brown-grey sandstones and shales of the same character as those already described on the other streams dip S. to S. 30° W. $<$ 30°–80°, and extend up stream, and at forty-five chains from the overlap of the Trias show an anticlinal structure, the opposing dips being S. 20° W. $<$ 80° and N. 20° E. $<$ 50°–60°. Thence to the centre of the synclinal a breadth of seventy-five chains is occupied by similar strata, dipping generally N. 15°–20° E. $<$ 45°. North River. Folly River.

Above the road from Folly Mountain to the East mines, the strata are much disturbed and the dips irregular. A series of grey sandstones, shales and conglomerates are exposed for twenty-five chains which very closely resemble the lower portion of the Millstone-grit. They are unconformably underlaid by hard, green Lower Carboniferous conglomerates, which form high cliffs and extend up stream for twenty chains, where they rest upon the band of black shale and associated iron ore rocks. A fault is evident here which throws this band back to the north for twenty chains. Should the rocks above the bridge be of Millstone-grit age they are exceedingly local, since no trace of them is Black shale. Fault.

visible either to the east, at the East mines, or west in the direction of the Great Village River.

Between Pine Brook and this point the Lower Carboniferous sandstones and conglomerates are well exposed at several places. They dip uniformly S. 30° E. < 40°-50°.

Contact of Triassic and Lower Carboniferous.

The line of separation between the Triassic and Lower Carboniferous crosses the Intercolonial railway, one mile and a fourth west of the Folly River. Thence to Londonderry station an anticlinal structure is apparent, the opposing dips being S. 30° W. < 70° and N. 30° E. < 45°.

Great Village to Londonderry mines.

The road from Great Village to Londonderry mines keeps along the east bank of the Great Village River and affords a good section. The contact with the Trias is near a small brook, about a fourth of a mile north of the road leading to the Londonderry station. The first outcrops, underlying the Triassic, are dark red conglomerates and sandstones, the former containing pebbles often of large size. These extend for 1960 paces to a fault, the dip being generally southerly at an angle of 20°. North of the fault the dips change to a northerly direction at angles of 40° to 50°, which continue to the crossing of the East Branch just south of the mines village, the last ledge consisting of brown shale and sandstone, dipping N. 55° E. < 15°.

Londonderry mines.

On the other side of the brook, ledges of grey, coarse grit and conglomerate with grey shale, containing plant remains, often of large size, dip S. 25°-30° E. < 45°. They are entirely distinct in character from the Lower Carboniferous strata already described and have a strong Devonian aspect. These beds cross the East Branch between the road and the foot of the dump, where they form a cliff on the west side of the stream. Patches of red Lower Carboniferous conglomerate rest unconformably upon them in places, both along this stream and on the road round the spur of the hill on the west side of the river, not far from the manager's house. Two distinctly unconformable formations are here exposed, the upper of which dip S. 80° E. < 40°. The underlying beds which are like those of the ridge between Truro and the Stewiacke valley are possibly the equivalents of the hard quartzose beds noted in the lower part of the Debert River section. They also occur further west, in the vicinity of Economy and Five Islands. Their relations to the unconformably overlying Lower Carboniferous measures will be presently described.

Londonderry mines to Economy.

Between the mines and the Economy River, the exposures are few. The Lower Carboniferous extends continuously in this direction as indicated by their presence on the road from Port-au-Pic to Castlereagh Settlement, and westward at Pleasant Hill in the rear of Upper Economy.

The sections on the Economy River and in the roads in the vicinity, display a considerable diversity of lithological character in the various groups exposed between the Economy falls and the shore. On the road leading back from the shore road, one mile west of Upper Economy, after passing over the Trias, which has a breadth of three-eighths of a mile north from the main highway, we ascend a ridge having an elevation of 450 feet. On the south slope of the hill, reddish-brown sandstones, shales and conglomerates are exposed in the gullies alongside, with a southerly dip at angles of 45°. These extend for about fifty-six chains to brownish-grey altered shales, which dip N. 55° E. < 40°. The exposure here is limited, but along the top of the ridge, pieces of grey quartzite and slates, of a much older aspect than the rocks first seen, are met. These extend down the north slope of the ridge till we approach the valley, when bright red sandstones and conglomerates, the extension of the upper members of the Lower Carboniferous from the east, come in. These have a breadth of a mile and a half, and occupy the valley of the east branch of the Economy River. Road up Economy River

The road up this stream keeps close to the west bank for a couple of miles, or to the bridge, where it crosses to Pleasant Hill. Here the bright red sandstones, just noted, are again seen, and have a breadth on the river of 120 chains, and thence extend west to Five Islands. The dip at the bridge is N. 30° W. < 40°. One fourth of a mile below this bridge the rocks, which constitute the ridge, described on the other road are met, and consist of grey shales and hard, brownish-grey and grey quartzite or quartzose sandstone, distinct in character from the beds of the Lower Carboniferous of the sections to the east. They are distinctly unconformable, not only to the bright red sandstones and conglomerates of the Pleasant Hill settlement, but also to the ordinary brown sandstones and shales of the formation in rear of Upper and Middle Economy villages. Where traversed by the river, they present cliffs of considerable height, and have an exposed breadth of twenty-eight chains. They dip generally at high angles, 75° to 90°, and their strike is the same as on the top of the ridge two miles east. Pleasant Hill road.

At the point where the sharp bend occurs in the stream, one mile above the Economy road, a fault occurs, the rocks on the opposite side of which dip S. 15° W. < 50° to 80° and S. 80° W. < 40°. Below this, brown sandstone and brown and grey marls and sandy shale of Lower Carboniferous aspect, are exposed for twenty-seven chains, below which the country is flat to the shore. Faults.

The portion of the Economy River directly below the falls, which are four miles and a quarter north of Central Economy P. O., is occupied for 1,900 paces by brown sandstones, shales and conglomerates of the usual character, having a southerly dip at high angles, and rest Economy River

Iron ore rocks. upon the iron ore belt seen at the falls, and on the hillside to the west. Altered shales and quartzite like those described in the lower part of the stream then appear with an exposed breadth of only 100 yards. A fault is apparent between these and the strata to the north. The hard beds dip south $< 70°–90°$, and are overlaid unconformably by the bright red sandstones and coarse conglomerates already described. They are probably the equivalents of the altered series of the ridge lower down, and may form the outcrop of the northern side of a steep synclinal basin.

Unconformity.

Three unconformable series below the Trias.

It is evident from the difference in the character of the rocks on this stream as well as from the diversity of dips, that at least three unconformable series occur below the Trias. Of these, the upper, embracing the red sandstones and conglomerates, is undoubtedly a portion of the Lower Carboniferous, as it underlies the Triassic unconformably at several places. The second includes the brown and brownish-grey sandstones and shales with beds of grey and brown-red conglomerates, and while unconformable to the red sandstone portion just mentioned, is also a portion of the same formation. The third and lowest series, while distinctly unconformable to the other two, has, in addition, a much older and more metamorphic aspect, the shales being at times slaty and the sandstones quartzose and often a true quartzite. They are identical in character with the rocks of the ridge which extends between the Salmon River and the Stewiacke valley and which have been hitherto classed as Upper Silurian. They contain, however, plant remains at various points and on the whole resemble much more closely some of the plant beds of the Devonian of southern New Brunswick than either Silurian or Lower Carboniferous sediments.

Probable Devonian areas

Between Economy and Harrington Rivers, Lower Carboniferous sediments are exposed at rare intervals. They appear from beneath the Trias on the shore sixty-four chains below the mouth of Carr's Brook and extend for half a mile. A small outcrop is also seen in the brook mentioned at three-fourths of a mile above the road. Between this and Lower Five Islands, ledges are apparently wanting, but the debris on the several roads and the character of the soil shew the continuance of the formation in this direction. On the Bass River it has a breadth of one mile, beyond which it is probably terminated by the underlying quartzite series.

North River.

The North River, a small stream one mile east of Harrington's River, affords a good section of the rocks of this series which have generally been considered as a part of the Lower Carboniferous formation. Upon examination, however, they are found to be mostly altered shales and quartzites of the underlying unconformable series, described on the Economy River to the east. The strata are well

exposed on the stream between the road and the falls, 130 chains up, or to the contact with the old schists of the Cobequid series, and are as follows:—

At the road, and for ten chains north, fine red conglomerates, sandstones and shales of presumably Triassic or Carboniferous age. Then hard brownish quartzites, with sandstones and shales containing traces of plants, cordaites, &c., identical with the quartzite series south of Truro, dip N. 30° E. < 40°, with grey, micaceous, sandy slates and slaty shales and sandstones, in places a hard quartzite also containing plants, same dip, to centre of synclinal basin. Rocks of Devonian aspect.

The exposed breadth of these rocks is sixty chains and the estimated thickness is 2,500 feet. Thickness.

On the north side of the synclinal these beds are repeated, the dip ranging from S. 10°–20° W. < 30°–70°, and are distinctly and conformably underlaid by the greenish-grey quartzite and slates of the Londonderry mines series which here carries veins of iron ore of considerable size. The black carbonaceous shale band is here a part of the series which holds the iron ores. Iron ore.

West, on the Harrington River, near the crossing of the road to Parrsborough, similar greyish and brown quartzite occur, the extension of this area. Both lithologically and stratigraphically they are distinct from the ordinary sediments of the Lower Carboniferous in this direction, and are, as stated, more like beds which have been designated Devonian in New Brunswick.

Beyond this, in the direction of Parrsborough, the two series have not yet been separated.

DEVONIAN.—F.

No rocks which can be assigned to this horizon were observed by us on the north side of the Cobequid range, but on the southern flank at several places, strata, intermediate in position between the iron ore belt and the Lower Carboniferous, and distinctly unconformable to the latter, occur. They have a strong Devonian aspect, but as their character and relations have been pretty fully considered in the last chapter, and as further examination will be necessary to fix their precise horizon, their further discussion may be for the present deferred.

SILURIAN.—E.

On the north side of the Cobequid range, the only area of this age recognized by us was at Wentworth station, on the Intercolonial railway, and for rather more than a mile west. As here exposed, the following characters are presented:—One hundred paces south of the

Wentworth station.

station, greyish conglomerates, apparently felspathic, are indistinctly seen on the west side of the track. Their relations to the fossiliferous slates are somewhat difficult to determine, but they probably underlie them unconformably and belong to a distinct group. They are succeeded directly to the south by the syenites of the mountain. West of the station, a cutting occurs in soft greyish and dark bluish-grey rubbly shales, which are traversed by several dykes of hard, green dioritic rock, often epidotic (diabase). These cut the beds transversely and have shattered and otherwise altered the shales with which they are in contact. The fossiliferous rocks are thence exposed to a point on Caldwell's Brook, 112 chains from the station, where their contact with the Lower Carboniferous is seen in the tunnel under the railroad. The most westerly exposures consist of hard slates of a greyish color and with a yellowish tinge in places, and are apparently more altered than those near the eastern end of the section. They dip S. 40° E. $<$ 30°, and on Caldwell's Brook have a breadth exposed for 150 yards, being terminated at an old mill just south of the railroad by ledges of reddish syenite. On Whetstone Brook, twenty-three chains west of the station, these rocks are observed for one-fourth of a mile below the railway, having a dip at the northern edge of S. 20° E. $<$ 35°. This is at the forks of a small branch from the west, below which Lower Carboniferous sediments occupy the stream.

Dykes.

The Silurian rocks of this locality lie in the form of a narrow basin, the reverse dip to the north being seen in the first cutting near the station. The fossiliferous beds, therefore, of that locality, occupy the centre of the synclinal, while the rocks of Caldwell's Brook, to the west, probably represent the lower members.

East of Wentworth, as far as the French River at least, these rocks have not been seen by us on the north side of the mountains, nor do they appear, in so far as known, to the west of Caldwell's Brook, being either entirely absent or covered over by the overlapping Lower Carboniferous beds.

From the collection of fossils made in 1873 by the late Mr. W. McOuat, the age of this outlier was determined by the late Mr. Billings as probably that of the Clinton. The species recognized by him in Mr. McOuat's collection were as follows. (See Report of Progress, 1874–5, page 10.)

Fossils.

Graptolithus, allied to *Gr. Clintonensis*. Hall.
Lingula oblonga. Conrad.
Leptæna transversalis. Dalman.
Strophomena corrugata. Conrad.
Rhynconella Eva. Billings.
Atrypa reticularis. Linnæus.

From a small collection made during the past summer the following species were determined by Mr. H. M. Ami, B.A.:—

Lingula oblonga. Conrad.
Strophomena rhomboidalis. Wilckens.
Orthis. Sp. undet.
Leptocœlia. " "
Atrypa reticularis. Linnæus.

Fossils.

These confirm the conclusions of Mr. Billings in 1873.

The same view has also been taken by Sir Wm. Dawson in the supplement to the Acadian Geology, 1878, page 75, where a list of fossils similar to those above enumerated is given.*

Iron ore series of Londonderry mines.

On the south side of the Cobequid range the belt of rocks containing the iron ores of the Londonderry mines and vicinity have a very extensive development. They were found during the past season to form a continuous band, from the road leading from Truro to Tatamagouche, west to the Harrington River, good exposures being seen on every stream section, and from the observations of Mr. Scott Barlow, further west, it is evident they extend almost to the extremity of Cape Chignecto. Throughout their whole extent, the rocks can be easily recognized, not only by the presence of ores of iron, in greater or less quantity, but by their lithological character. They are greyish and brownish-grey quartzites, with grey and brown shales, and others of greenish shades, while a belt of black graphitic shale is found along the southern border almost continuously throughout its whole extent.

No fossils have yet been observed in the area examined by us, and it is, therefore, very difficult to pronounce definitely as to their age. In lithological characters they very closely resemble Devonian rocks of other parts of the province as well as of New Brunswick. The researches of Sir Wm. Dawson and Dr. Honeyman in the county of Pictou, on what they consider the equivalents of this belt, tend, however, to shew that they belong to the horizon of the Silurian, but as this area is for the most part beyond the limits of the accompanying sheet, discussion as to the exact age of the rocks in question is deemed unnecessary, pending further examinations during the coming season. The characters of the rocks and associated ores are given in detail in Acadian Geology, 1868, and Supplement 1878, also in Report of Progress, 1872–3, page 19–31.

The fossiliferous Silurian strata of Earlton, referred to by Sir Wm. Dawson, supplement to Acadian Geology, page 75, have not been seen

* From a paper on this locality read by Dr. Honeyman of Halifax, in 1873, (see Transactions of the N. S. Institute of Natural Science, Vol. III, page 353,) it will be seen that that gentleman dissents from the views above expressed and claims that these rocks should be assigned to a lower horizon, probably Hudson River.

in the area included in the present report, the rocks underlying the Carboniferous basin on the French River and its branches being talco-chloritic schists and felsites, which will be described in the chapter on pre-Cambrian.

PRE-CAMBRIAN.—A. B.

The pre-Cambrian of eastern New Brunswick, embraced in the accompanying map, is confined to the county of Albert, and represents the eastern extension of the great pre-Cambrian area of the southern part of the province, which terminates a short distance west of Demoiselle Creek. Good exposures are seen on the roads, leading north, from Hopewell Corner and Hopewell Hill, which cross the range of the Caledonia Mountains. In character they are similar to those in Kings and St. John counties, and are fully described in previous reports, 1877, and later. They consist of hard green and purple slates, talco-chloritic and micaceous schists, red flinty felsites and fine-grained gneiss, often hornblendic, syenites and granites, sometimes protogine, with green, often epidotic, diorites. The dip is generally northerly, on the south flank of the range, at about an angle of 50°, rising, however, near the summit of the mountain, to 90°. The surface breadth of these rocks, as here displayed, is nearly eleven miles, which, with an average dip of 50°, would present the enormous thickness of 43,500 feet. The structure is, however, probably an overturned synclinal, as has been shown to be the case in Kings and western Albert.

Characters of the rocks in Albert county.

A small outcrop of these rocks is also seen on the road leading from Hopewell Hill to Curryville, in rear of Shepody Mountain. They consist of purple and green chloritic and talcose schists, sometimes containing epidote, and are exposed for about three-eighths of a mile along the road. They are flanked by Millstone-grit sediments on the north and east, and by the Lower Carboniferous conglomerates of Shepody Mountain on the south. They dip N. 5° E. $<$ 50°.

In the Geological Survey Report, 1877-8, page 6 D, a reference is made to a supposed outcrop of pre-Cambrian rocks on the Beech Hill road, east of Memramcook Corner. Re-examination shews this area to consist of drift pieces only, and the underlying formation to be Carboniferous.

In the province of Nova Scotia, the area included in this formation embraces the greater part of the range of the Cobequid Mountains, which extend, from the south-west extremity of Cumberland county, east into Pictou. North of Minas Basin, the average breadth of this belt is about eight miles, which, in its western extension, becomes somewhat reduced. During the past season, a number of sections were made across the range, along the streams which take their rise in the numerous lakes found along the top of the mountain ridge, and flow south to

Various streams examined.

Minas Basin or north to the strait of Northumberland. Among those on the south may be mentioned the Chiganois, Debert and Folly, east of the Intercolonial, while to the west, the Great Village, Economy and the streams in the vicinity of Five Islands, were examined. On the north, sections were made on the Mill Brook, which heads near Debert Lake, and on the several branches of the French River, as well as on the Intercolonial railway. On all these streams excellent opportunities are presented for studying the structure of the mountain chain, as well as along several of the roads which cross its summit.

Similarity of the Cobequid series to the Pre-Cambrian of New Brunswick.

In general, it may be stated that in lithological character, the Cobequid series is almost identical with the pre-Cambrian of southern New Brunswick, consisting of a great thickness of crystalline rocks. Among these are large areas of syenite and diorite, the former both red and green or the protogine of the New Brunswick series, often epidotic, red crystalline felsites sometimes porphyritic, schists of various kinds, chloritic, talcose, micaceous and hornblendic, quartzite, gneiss and hard green slates with crystalline limestone. The schistose portion apparently rests upon the syenites and diorites, which seem to constitute the bulk of the central and northern areas. On the north the series is overlaid, at Wentworth, by the fossiliferous Silurian just described, and, elsewhere, by Lower Carboniferous sediments, while on the south the belt of rocks containing the iron ores extends along its whole length in unconformable contact.

Section on Debert River.

The upper part of the Debert River and the road connecting with New Annan shew well the character of the rocks now under consideration. Beginning at the contact with the iron ore belt, we find—

Hard green felspathic slaty schist, in places slightly pyritous. Dip S. to S. 10° W. $<$ 80° to 90°.

Hard greenish and greyish felspathic rocks, in places a pure felsite, chloritic, with masses of diorite and syenite, the former often coarse.

Brownish-grey and reddish-grey felsites, sometimes schistose, green schistose slates. Some of the beds a white felspathic quartzite, with coarse grey diorites and fine reddish syenite.

Felspathic quartzite, whitish-grey felsitic schists and diorites, in upper portion the felsites are gneissic. S. 35° E. $<$ 75°.

Hard greenish felsites, greyish gneissic and hard, whitish-grey, felsites, with quartz. The felsite much jointed in sharp square blocks. Hard green felspathic schist. S. 20° E. $<$ 75.

Grey felspathic gneiss, with diorites and schistose slates, to falls over fine-grained, massive green diorite.

Gneissic felsite cut by diorite dykes.

Fine-grained syenite (hornblendic).

Reddish gneiss and protogine syenite.

Protogine granites, green slates, and fine green diorites.

Green chloritic schist, S. 35° E. < 60°. Talco-felspathic schist, S. 15° W. < 55°. Hard bluish-black rubbly feslpathic slaty schist, S. 15° W. < 40.
Hard green schist with epidote. S. 30° E. < 50°.
Hard green epidotic diorite, with green schist, to McMullins' mill.
Dark greyish-green altered slates. S.20° E. < 65°.
Dark green crystalline diorites.
Greyish-green hydromica schists. S. 5° E. < 30°.
Chloritic schist. S. 50° W. < 65°.
Red syenites and fine-green diorites, with occasional bands of schist to Debert Lake.

On the upper part of Mill Brook, which completes the section to the New Annan road, the only rocks seen were:—

Fine-grained, dark-green diorite, sometimes porphyritic.
Brownish-red, porphyritic felsites.

Road from Debert River to New Annan.

The road from McMullin's mill to New Annan shews, at the crossing of Shatter Lake Brook or east branch of Debert River, large ledges of green talcose and chloritic schist, dip S. 30°-50° E. < 40°, resting upon reddish granite. Thence, to within a short distance of the rear road in West New Annan settlement, ledges of red felsite, syenites and green diorite, with occasional bands of green chlorite schist, are seen. The syenites are occasionally greenish, resembling the protogine of southern New Brunswick. A gneissoid structure is seen at several points.

On the brook flowing from Byer's Lake, the prevailing rock is finely crystalline, dark-green diorite, which is intimately associated with reddish porphyritic felsite and with gneissic hornblendic rock. The diorite often contains much epidote.

Pine Brook.

A second section measured on Pine Brook, a branch of Debert River, disclosed the presence of strata similar in character to those just described. They consist of chloritic, talcose, hornblendic and felspathic schists, schistose gneiss, hard, green felsite, greyish-white felspathic quartzite and true gneisses, with fine green diorite, resting, as on the Debert, upon the nucleus of dioritic and syenitic rocks. These are all very strongly pre-Cambrian in their aspect.

On the Folly River, after passing the Lower Carboniferous sediments and the belt containing the iron ore, the first rocks of the mountain series are dark-green crystalline diorite, with a band of hard greyish-white felspathic quartzite. Thence ascending the stream we have:—

Diorites, reddish gneiss and schist, S. 20° E. < 55°. Green chloritic schist and fine, hard green slates. Fine, green crystalline diorites, with hard, fine, green schistose slates.
Hard green chloritic, felspathic and hornblendic schists, with small veins of white quartz.

Green and grey, hard felspathic schist. S. 40° E. < 45°. Schists, chloritic, micaceous and hornblendic, with slaty diorites.
Thence to foot of Folly Lake, hard, green diorites, mostly fine-grained, hard, green slate, and occasional bands of chloritic and hornblende schist, occupy the stream.

A similar series of rocks is found on the Intercolonial railway in the several cuttings, south of the Lake, except that fewer schists and slates are visible, the cuts being principally through the crystalline volcanic portion, fine-grained diorite, epidotes, &c. Section on Intercolonial railway.

A paced section was made along the railway between Wentworth and Londonderry stations. The portion between Wentworth and the Folly station, which embraces the northern and central portions of the range, discloses principally syenitic, dioritic and felspathic rocks. These are often intersected by transverse dykes of granite. The prevalence of epidote will be at once seen by reference to the section below. The first rocks, after leaving Wentworth station, are apparently:—

	PACES.
Syenitic, hard greenish-grey and dark grey, composed of quartz, felspar and hornblende, then hard fine-grained diorites, with reddish-brown felsite, sometimes porphyritic, the whole series containing epidote in considerable quantity, and extending	655
No exposures	794
Fine epidotic and red porphyritic felsite	224
No exposures to large brook	83
Hard, green diorites	532
Red, moderately coarse, syenite	260
Red, fine syenite, almost a pure felsite	122
Hard grey diorites, red syenites, felsite and epidotic diorites to end of cutting	330
No exposures	341
Fine-grained diorite, with veins or dykes of red felspar and fine-grained granite	60
No exposures	580
Hard coarse diorite, with large crystals of black hornblende and felspar—bright red felspathic granite with scattered grains of quartz, epidote and hornblende	220
No exposures	70
Red felspathic syenite and fine green diorite	535
No exposures	414
Hard, fine-grained red felspathic syenite	1330
Fine green diorite and red, fine-grained syenite, almost a felsite..	1100
To head of Folly Lake.	

The red syenites of this section are largely composed of red felspar, with very sparsely disseminated grains of quartz. In places the rock is a red felspar porphyry. These are apparently cut by dykes of fine green

diorite, often of small size. The coarse hornblendic diorites are much more extensive. The schistose rocks seen on the southern flank appear to be absent from this part of the mountain, which stratigraphically underlies them.

Breadth of the Cobequid series.

The entire width of the crystalline portion of the range from Wentworth station south to the the overlap of the iron ore belt is 640 chains. Of this space, nearly seven miles is occupied by the dioritic and syenitic rocks just described, the overlying schists, which compose the south flank of the range, being rather more than one mile in breadth.

Similar rocks in the same order of succession are seen on the roads and streams north of the Londonderry mines.

Road from Port-au-Pic to Sugar Loaf Mountain.

Further west, on the road from Port-au-Pic to Sugar Loaf Mountain, the first rocks of the Cobequid series are blackish hornblendic gneiss, composed of quartz, felspar, hornblende and mica, dipping S. 35° E. < 75°, then going north we have—

Hard, fine grained diorite, green and purple shades.
Talco-chloritic and gneissoid felspathic schists.
Diorites and syenites, containing hornblende.
Green chloritic schists and slates.

These latter extend to within a mile of the county line. Here on the farm of R. Fulton, red slates resembling in character the reddish slates of the Quebec group are seen, but their area is exceedingly limited, having a breadth of about one-fourth of a mile and extending only for a few hundred yards. They are, probably, a portion of the mountain series. Diorites again come in and extend to the county line.

North of this, the road runs through the woods till it joins the road from River Philip to Londonderry. Exposures are not numerous, but where seen consist of green epidotic diorites and syenites with occasional bands of green schist, the most northerly exposure at the overlap of the Lower Carboniferous being red syenite. This is sixteen chains from the cross-road on the east branch of River Philip. The section further west on the road from Maccan River to Five Islands discloses a like succession, the granites and diorites occupying the northern and central portions, while the schists constitute the south flank.

Five Islands to Maccan River.

Spring Hill and Parrsborough railway.

On the line of the Spring Hill and Parrsborough railway, the first rocks underlying the Lower Carboniferous on the north side are hard greenish-grey and green felspathic slates, much altered and with patches of white quartz. Further south they apparently become more felspathic, weathering a dirty pinkish grey, and with disseminated crystals of pinkish and grey felspar, constituting a true feldspar por-

phyry. Large veins of white quartz occur at intervals. In the vicinity of the lake, near the lower end of the pass, red felspathic syenites and fine green diorites are seen, and at a mill on a brook coming from the east, green chloritic schists of pre-Cambrian aspect appear. South of this, the only rocks on the railway are apparently reddish felsites, often hard and porphyritic, a true felspar-porphyry, in some places having a purple tinge. They extend to the flat which lies between the mountain range and Parrsborough village, where, owing to the dense covering of gravel, no ledges are visible. The schistose belt, so conspicuous in all the eastern sections, is here largely wanting, owing probably to the denudation of the southern slope of the mountain.

The western end of the range on the Bay of Fundy discloses a series of rocks very similar to that between Wentworth and Folly Lake, except that the crystalline felsites are more extensively developed. Like the last, the schistose portion is largely wanting. The first exposures are on the south side of Spicer's Cove and consist of hard crystalline and porphyritic red felsites. Between this and Cape Chignecto, felsites and syenites, with occasional large masses of epidotic diorite, occur. Dykes of fine-grained syenite and felsite also cut the rocks along the shore and extend inland for some distance. Bands of dark-green dioritic slates and schist occur at intervals. At Spicer's Cove the dip of the felsites seem to be S. 25° W. $< 80°$, and this is the general inclination along the whole of this section. This portion of the coast is so rough that accurate measuring along the shore is impossible, and the strong tidal currents render boat navigation dangerous.

Spicer's Cove to Cape Chignecto.

In the Cobequid series just described, no reference has yet been made to the crystalline limestones. These occur at several points, more particularly in rear of Five Islands on the North River and between Londonderry mines and Port-au-Pic. At the former locality the marble is found in the stream about two miles from the mouth and 330 paces north of the main fall which marks the boundary between the pre-Cambrian and the iron ore belt. The rock, much of which is beautifully white and crystalline, is associated with red syenite, green felspathic schist and hard slates. Small dykes and veins of diorite have so shattered it as to render the ledge practically valueless for obtaining large blocks. A short distance further up stream the marble is greenish-grey and serpentinous, and in places traces of asbestos are found. The width of this ledge is from ten to twelve feet, but it has not been traced beyond the bed of the river. The marble of this place occurs associated with green talco-felspathic schist, probably as an integral portion of that belt.

Crystalline limestones of Five Islands.

About four miles west of Londonderry mines, on the property

Crystalline limestone near Londonderry mines.

perty of D. and A. Morrison, Cumberland road, and about two miles from the new mines, large outcrops of white marble resembling much of that in the vicinity of St. John, New Brunswick, are seen. It occurs on the south flank of the mountain apparently overlying the schists. A large quantity was taken out some years ago for use at the iron works and is yet lying along the tramway to the new mines. It would, undoubtedly, make a fine quality of lime, but little use has as yet been made of it for that purpose. *

It will be observed from the foregoing that the rocks of the Cobequid range in their lithological character and crystalline structure present, as stated, a marked similarity to the so-called pre-Cambrian of southern New Brunswick. The stratigraphical arrangement of the various groups may be thus briefly given.

1st. The mountain range proper, presenting a series of red syenites, generally fine grained and felsitic, red felsites, crystalline and often porphyritic green diorites, often fine grained and epidotic, but occasionally coarse grained with large crystals of hornblende. These form the great bulk of the chain.

2nd. A considerable thickness of schists, schistose felsites, gneisses and protogine granite, with hard green slaty schists, resting generally upon the southern slope of the mountain, but appearing also at some points on the north side.

3rd. Crystalline limestone, both white and serpentinous, resting generally upon the south flank of the schistose series.

Schists of French River and vicinity.

A second, but limited area of schists, is seen at New Annan, on the north side of the Cobequids, which resemble in many respects those already described. They are talcose and chloritic and cut by numerous irregular quartz veins, some of which are reported to be auriferous. They are well exposed on the Four Mile Brook, a branch of Waugh's River, and on the several branches of the French River. In rear of Byer's mill they form the elevation known as Baxter's Mountain, the west face of which presents a bold front overlooking the Byer's Mill Brook. The dip is N. 25° E. $< 75°$. Thence they cross the stream and extend north-westerly in the direction of Wentworth for several miles. On the east branch they have a breadth of one mile, and rest upon trappean rocks, the dip at the contact being N. 20° W. $< 40°$, changing in a short distance to north-east, which direction is generally maintained, though there is a low anticlinal about midway on the exposure.

* From the association of the latter deposit with black shales and quartzites of the iron ore series, it is probable that this band of limestone may belong to the Silurian beds of the vicinity instead of the pre-Cambrian, the immediate cause of alteration cannot, however, be determined.

This belt is separated from the syenitic and felsitic masses of the Cobequid series proper by an area of trappean rocks which appear to be of more recent date than the schists, and to have been thrust up between them and the red felsites. Their contact with the latter is well seen in Irving's Mountain and at the forks of Byer's Lake Brook and Whirlewha Lake. They extend from the road leading to Truro from Tatamagouche, north-westerly for over six miles. The trap varies considerably in character, in places being reddish and felspathic, while the great mass is either rubbly and irony or dark greenish-grey and amygdaloidal. At the contact with the schists on the east branch of French River, at Mr. Swan's mill, there is a bed of decomposed trap or red ochre with lumps of ironstone, the whole being two to three feet thick, separating the two formations. On the old Chiganois road, now abandoned, these rocks have a breadth of over two miles, but their outline is very irregular. Trap rock.

Igneous Rocks.

Trappean rocks of various kinds penetrate sediments of Triassic and Carboniferous age at various points. In New Brunswick the only observed exposure of this kind in the area under discussion was noted some years ago by Prof. Bailey on Calkin's Creek (Demoiselle Creek?) a short distance back from the road leading from Hopewell Cape to the hill. The rock is coarse, dark green, nodular and columnar, and contains small veins of magnetic iron of an inch in thickness. The dyke penetrates reddish-grey shales which at the contact have been altered to the aspect and hardness of chert.

On the north side of Minas Basin and channel, areas of trap are found at many points, among which may be mentioned Cape d'Or, Spencer Island, Cape Sharp, Partridge Island, Clark's Head, Moose River, Gerrish Mountain and the chain of the Five Islands and Port-au-Pic Mountain. These are separated by areas of Carboniferous and Triassic rocks, and though now detached are without doubt the eastern extension of the great trap overflow, which has formed the North mountain range of Kings, Annapolis and Digby, on the south side of the Bay of Fundy. Beautiful specimens of the various zeolites, calcite, amethyst, agate, &c., are found, as well as veins of magnetic iron, sometimes of considerable size. The latter has been opened in Gerrish Mountain, near the road from Economy to Five Islands, and a quantity of the ore extracted and sent to the Londonderry mines. The cost of transport would, however, seriously affect its economic value. The trap area of this locality has an extension of five miles and a quarter from Indian Point to its terminus, midway between the villages of Central and Lower Economy, and forms a prominent ridge with an Areas of trap around Minas Basin. Iron ore.

elevation of 300 to 450 feet. Seaward it extends through the group of the Five Islands in the direction of Blomidon. The section presented on the shore at Indian Point shews the trap to have burst through red shale and sandstones, presumably of Triassic or Permo-Carboniferous age, in a dyke 210 paces wide, which has ascended and then overflowed the soft red shales in either direction. The contact of the two formations is well seen in the cliffs at this place, the trap occupying the upper part for 1,080 paces, gradually descending till it reaches the beach at the neck of the dyke, while the red stratified beds occupy the lower portion. The greatest breadth of the overflow on the mountain is 100 chains.

Gerrish Mountain.

Moose Island, and one other of the chain to the west, show also both formations, the trap occupying the north side and the shales and sandstones the south.

Port-au-Pic Mountain.

Port-au-Pic Mountain, eleven miles east from this area, is a roughly egg-shaped mass of trap, with a length of 114 chains and a breadth of sixty-five at its eastern end. In character it is like the other traps of the Minas Basin, sometimes amygdaloidal, at others massive. It is flanked on the south by fine reddish conglomerates, which may mark the lowest members of the Triassic formation, but is not far from the contact of that formation with the Lower Carboniferous.

The characters and distribution of the trap rocks of the upper part of the Bay of Fundy, including the Minas Basin, are so fully given by Dr. A. Gesner in his "Remarks on the Geology and Mineralogy of Nova Scotia," 1836, and later by Sir Wm. Dawson in "Acadian Geology," 1868, that further descriptions are not here considered necessary. Though always regarded as Triassic in age, they must belong to the close of that period, since they are found to have broken through and overflowed that formation at many observed points. Their action upon the sediments through which the dykes pass is very slight, the metamorphism extending, in no observed case, more than a few feet from the line of contact.

Dioritic dykes in the Silurian.

Dioritic rocks occur at many points, in connection with the iron ore belt. These are, however, apparently a distinct and older set of intrusions than those just described, differing greatly in character. They are generally green and fine-grained, and are more of the nature of the dykes that penetrate the Silurian and older rocks. It may be doubted if the metamorphism seen in these strata is due so much to these intrusions as to other and more general causes.

Throughout the range of the Cobequids, dioritic and syenitic dykes are common. In the vicinity of Wentworth station the former, which are of the nature of a diabase and frequently contain epidote, cut transversely across Silurian fossiliferous rocks, altering them to some extent near the contact.

In many cases the dioritic and syenitic masses appear as an integral part of the mountain series, having a marked resemblance to similar rocks recognized in the pre-Cambrian of New Brunswick and of parts of Nova Scotia. They often constitute large areas and are well exposed on the railroad between Wentworth and Londonderry stations. In places along the railway, dykes of red felspar, porphyry, and reddish granite, cut the dioritic and syenitic rocks. The same is also seen on the coast in the vicinity of Cape Chignecto. Large masses of diorite, generally fine-grained, greenish and grey, are also found associated with the schistose series of the south side of the mountain range.

Dykes of diorite and felsite in the Cobequid series.

In the vicinity of the Spring Hill mines, the ridge to the east, known as Claremont Hill, though for the most part covered with Carboniferous sediments, is undoubtedly a mass of red syenite, as can be ascertained by the quantity of debris along the road up the west slope of the hill. The conglomerates of the northern side and summit are also largely made up of large angular blocks of syenite in a reddish syenitic paste. It does not appear to be connected with the range of the Cobequids, but is apparently an isolated mass.

Syenite of Claremont Hill.

The area of trappean rocks in New Annan has already been referred to at the close of the chapter on pre-Cambrian. Their age is uncertain, but from their amygdaloid character they more closely resemble the Triassic traps than the fine-grained diorites of the older formations. Where observed, the trap was in contact with talcose schists, on the one hand, and hard crystalline red felsites on the other.

Traps of New Annan.

In New Brunswick, the area of syenite on the Memramcook River has been referred to in the Geological Survey Report, 1876–7, page 378. The rock is reddish, partly fine-grained, but generally coarsely crystalline and porphyritic. It is pre-Carboniferous, as the lower beds of the Lower Carboniferous in this district are largely made up of its debris.

SUPERFICIAL GEOLOGY.

This branch of the subject has, to a certain extent, been discussed by Mr. R. Chalmers in his report on the Superficial Geology of New Brunswick, and all the data obtained by us, relating to striæ and ice action, have, in so far as relates to that province, been given to him. In Nova Scotia, north of the Cobequid range, striæ, with a direction S. 63° W., were observed on the road from River Hébert to the South Joggins. This may indicate the course of the ice sheet which assisted in the denudation of the upthrow of the Spring Hill coal seams, and which, like those whose traces are seen following the valleys of the Petitcodiac and Memramcook Rivers, and in the vicinity of Aulac, joined the main stream which flowed down the Chignecto Bay and out by the Bay of Fundy.

Striæ in the vicinity of the Joggins.

Probable course of ice-sheet through the Cobequid

In the pass through the Cobequids now traversed by the railway from Spring Hill to Parrsborough, striæ were observed in the course of the gap, but whether the ice-flow was in the direction of the latter place or towards Maccan could not be determined. Probably th former, since on the south slope of the mountain at New Mines, west of Londonderry, an escarpment of rock, dipping S. $< 50°$, has its face beautifully striated in an east and west direction, following the course of the range towards the outlet of Minas Basin, and into which the Parrsborough valley stream might have discharged.

Striæ in New Annan.

In New Annan, on the north side of the mountain, grooves and striæ, in dioritic rock, were noted, course N. 10° E., or down the valley of the French River to Tatamagouche Bay.

Owing to the generally wooded and unsettled character of the Cobequid range, ice markings are very rarely seen, while the generally soft sandstones of the areas on either side disintegrate so readily that, except on freshly uncovered surfaces, they are apparently entirely absent. The remarks of Mr. Chalmers on the distribution of ice sheets in New Brunswick will doubtless apply equally to Nova Scotia. The frequent divergence of the striæ points, to some extent at least, to the action of local glaciers following general lines of depression, such as river valleys and the slopes of local water-sheds.

Character of soils.

The soil of much of the country underlaid by the soft red rocks of the Upper Carboniferous and by the sandstones, shales and limestones of the Lower formation, is generally of excellent quality. The same may be said of that formed by the decay of the Triassic along the north side of the Basin of Minas. But on the ridge of the Cobequids the hard granite and dioritic rocks produce a soil of no great depth and difficult to work; and being clothed with a dense growth of maple, birch and other hard woods, has been neglected for the more fertile areas around its base.

On the Millstone-grit areas also, the decay of the grey grits and sandstone produces a soil of little value, being generally sandy, and in places there are extensive barrens, especially in the area between Shoulie and Southampton, the favorite resorts of the moose.

Barren soils are also produced from the underlying grey quartzose sandstones of the Upper Carboniferous, such as the Ragged Reef band, the soil being a whitish quartz sand. This is also seen at places on Cape Maringouin, and in rear of Sackville, where this formation occurs.

There is, however, apparently, much good land available for settlement in the northern part of Cumberland and Colchester counties, lying in the first county between the Leicester road and the strait shore, and in the latter, to the south of Wallace and Tatamagouche, and now principally covered by a dense forest of spruce, generally of small size.

Gravel ridges are not very numerous, and in the flat country on either side of the mountains, not many stray boulders are seen. When found they are generally derived from the Cobequid range and consist of the hard rocks of that series.

A prominent ridge, however, extends northward along the west bank of the River Hébert, producing a marked feature in the otherwise generally level country. This has been referred to in Acadian Geology, page 82. It was examined during the past season by Mr. R. Chalmers, whose observations are herewith appended.

"A singular gravel ridge or kame called the 'Boar's Back' occurs on the west side of Hébert River, Cumberland county. About a mile to the north of Half-Way Lake, near the foot of the Cobequids, its southern end is reached, whence it extends northward seven or eight miles and is distinctly traceable to Atkinson Brook, near the head of the tide on the above mentioned river. Although its general course is nearly in a straight line, it has numerous local curves and sinuosities which give it a striking resemblance to a winding river course. Its height above Hébert Valley at the southern end is fifteen to twenty feet, at the northern, probably forty or fifty feet, the bottom of the valley having a gradual descent down stream, while the summit of the kame, which, by aneroid measurement, is 100 to 110 feet above high tide level in the Bay of Fundy, appears to be nearly horizontal. The kame follows the river closely and is continuous except where intersected by small streams. Branches run off from the main ridge at intervals, either extending along side of it for short distances, or diverging nearly at right angles therefrom and, after a few hundred paces, sweeping round to the general course of the principal ridge, enclosing hollows which usually contain peat bogs. The crest for fully half its length is little more than wide enough for a wagon road, but in other places it spreads out into terrace-like flats. As a rule, both slopes are steep—as steep as declivities, composed of sand and gravel, will remain stable under atmospheric action, without the materials sliding down from their own weight. Great quantities of boulders, from three feet in diameter downwards, wholly of local rock, that is, of grey Carboniferous sandstone and conglomerate, are interspersed through the sand and gravel. Generally speaking, they are well rounded, but a few were seen to be angular.

Boar's Back.

"The width of Hébert Valley is from a quarter to half a mile, and its depth, which increases northward, is, perhaps, 50 to 100 feet. The summit of the kame is, therefore, below the general level of the country on both sides of the valley.

"In the absence of any knowledge of its relation to the other Quaternary deposits of the district (our examination being merely a

cursory one), it is inadvisable to speculate regarding the origin of the kame, but its external characteristics and position with respect to Hébert River and the nature of the materials composing it, give it every appearance of a deposit laid down by rapidly flowing waters, and indicate, moreover, that Hébert River must, in some way, have been instrumental in its formation."

Economic Minerals.

Coal.—The workable coals in the area embraced in this report are, in so far as at present known, confined to the county of Cumberland and the Joggins and Spring Hill basins. In the former the principal collieries are the South Joggins, Minudie or River Hébert and the Chignecto. The output from the former, during the year ending December 31, 1884, was 25,034 tons, but changes in the working and management of the mine have lately been made, by which the output can be increased to 300 tons per day. The new works, which are one mile and a quarter east of the wharf, are down to a depth of 1,400 feet and are connected with the landing by an endless wire cable, by which the empty cars are hauled back to the slope, the loaded cars descending by gravitation. The parting of shale between the two seams here worked is decreasing in thickness to the east.

Joggins Coal mine.

River Hébert mine.

The Minudie, or River Hébert mine, has rapidly increased its output during the past year to 10,023 tons. It is located on what is probably the extension of the lower or Hard Scrabble seam, having a thickness of three feet nine inches.

Chignecto mine

The output at the Chignecto mine for the past year amounted only to 11,644 tons, the mine being idle for a good part of the time.

Milner and Maccan mines.

At the Milner and Maccan collieries, small quantities only were raised; at the former 155 tons, and at the latter, lately opened by Mr. Wm. Patrick, a short distance west of the old Maccan mine, only 94 tons. The seam at this place is a little under two feet thick. The relations of the seams on which these collieries are placed to the main Joggins seam has never been thoroughly settled, the thickness ranging from two to four feet, but they are capable of yielding a considerable amount of coal if economically worked.

Spring Hill mines.

The Spring Hill colliery is by far the most important in this section of the province, and though not worked to its full capacity, the total output during the past year exceeded by over 30,000 tons that of any other colliery either at Pictou or Cape Breton. There are four slopes known as the North, East, West and South. Of these the two latter are situated on the lower seam, the two former on the upper seam. The thickness of each of these is eleven feet, and they are separated by a vertical thickness of ninety feet. In addition, there are two seams of

thirteen and six feet overlying, and others of four feet and two feet and a half underlying. The description of these will be found in Mr. Barlow's report, 1873–74. The second eleven feet or upper seam was not at that time definitely located. The capacity of the four slopes is about 2,000 tons per day and the quality of the coal generally is excellent for house and steam purposes.

A new area on the South Branch of the Black River known as the Salt Springs mine was opened by a Truro company during the past season. A few tons only have been removed. The seam has been described in the remarks on the geology of the area, and at the outcrop has a thickness of two and a half feet. It was traced westward some years ago for one mile and a fourth by Mr. Barlow and Mr. Anderson and its thickness proved by three openings. It was found not to increase in value, but rather the opposite. (For details, see Report of Progress, 1875–76, pages 344–5.) **Salt Springs mine.**

The Oxford seam has already been described in the chapter on the Middle Carboniferous. **Oxford mine.**

The remarks on the Debert River area will be found in the chapter on Lower Carboniferous.

Iron Ores.—The only deposit of economic value in the area examined during the past summer was that of the Londonderry mines and their extension east and west. Careful surveys were made of all the openings both at the East and the New mines, as well as those in the vicinity of the iron works. The character of the ore varies, embracing limonite, hematite, specular ore, ankerite, yellow ochrey ore, resulting from the decomposition of the latter, and spathic ore, which is now being largely used. Analysis of these several ores will be found in the Report of Progress for 1873–74, pp. 231-233. **Londonderry mines.**

Full descriptions of the area have been given in Acadian Geology, pages 582-591, and in the Report of Progress, 1872-3, pages 19-31. The ore is extensively raised both at the East and New mines as well as at the village. A railway four miles in length connects the former place with the Intercolonial at East Mines station, while a narrow-guage railway con cts the new mines with the works.

Limestone for flux is brought from a Lower Carboniferous deposit, three miles south of Brookfield, or eleven miles from Truro. The amount of iron ore used during the year ending Dec. 31st, 1884, according to the report of the Department of Mines, was 54,855, and 5,799 tons of ankerite. The production of pig iron per day for the two furnaces was about 70 tons, but one of the furnaces was closed during the latter part of the season. The number of men employed was about 800. **Limestone for flux.**

Copper.—The deposits of this mineral, though numerous, are for the most part of little economic value. The most important is that near

Colonial copper mines, Dorchester.

Dorchester, already described in the body of this report. There is here a shaft 100 feet in depth, with galleries in all directions, employing about 45 men, and the mine has a good outfit of running machinery. The output consists principally of a hard, grey sandstone, impregnated, to some extent, with copper glance in a very fine state of division. A large amount has been extracted, but no returns are to hand regarding its economic value, which will depend entirely on the ability to concentrate the copper on the spot.

The openings at Malagash, Greenville, French River and other points seem to be abandoned, the irregular distribution of the ore being much against its successful working.

Gold.

Gold was reported from a quartz vein found in sinking a well in New Annan on the property of Robert Wilson, French River. The veins cut green chloritic and talcose schists, but are generally small and irregular. The gold, of which but a small sight was visible, was associated with iron pyrites.

Gypsum of Hillsborough.

Gypsum is abundant at many points throughout the Lower Carboniferous area. In New Brunswick, the great deposits of Hillsborough have long been worked by the Albert Manufacturing Co., whose works have a capacity of 600 barrels per day of calcined plaster, and give employment in the quarries and mill to about 100 persons. Large quantities of the crude gypsum are also exported. A deposit on the west side of Maringouin Peninsula has already been referred to. The gypsum is soft and fibrous, and occurring on the beach could be easily quarried and cheaply shipped. This area is understood to be in the possession also of the Albert Manufacturing Co.

At Nappan, Stewart's Meadow, Claremont Hill, River Philip, near Oxford and vicinity, Victoria Settlement, at the crossing of the road from Thomson station, Pugwash, Wallace Harbor, and Malagash, immense quantities of this material are exposed. They are practically undeveloped, the local demand being small, and the foreign market can be more cheaply supplied from the immense deposits of the Minas Basin and Cape Breton.

Limestone.

Limestone is quarried to some extent in the vicinity of Pugwash and shipped to Prince Edward Island, where it is burned. Local kilns are found at several points, but the supply of rock being practically unlimited the demand is not great. The largest deposits observed were on the road south-east from Amherst to Economy, on the Spring Hill Branch railway and in the vicinity of Pugwash and Wallace Rivers. On the south side of the mountain, the large deposits west of Londonderry mines, which is a true crystalline limestone, are available for lime burning.

On the Demoiselle Creek, in Albert county, N.B., large operations in

lime burning have been carried on for some years. The stone belongs Demoiselle Creek. to the Lower Carboniferous formation and the resulting lime is of excellent quality and has a high reputation all over the country. The great competition with kilns in the vicinity of St. John has to a certain extent retarded the progress of operations in this direction. Much of the limestone about Hillsborough is highly bituminous, and the quantity is practically unlimited.

The marble of Five Islands has already been described in the chapter Marble. on pre-Cambrian. It is, in so far as can be seen, so penetrated by diorites, and as a consequence so shattered, as to render the extraction of large sound blocks very doubtful.

Building Stone and Grindstone.—Of the former, quarries of excellent Building stones quality and of established reputation are found at many points throughout the Carboniferous area. In New Brunswick these are principally confined to the Millstone-grit portion, and occur at Curryville and other places along the Demoiselle Creek, at Boudreau and Rockport on the point between the Petitcodiac and Memramcook Rivers, and at Mary's Point and Grindstone Island in the upper part of Shepody Bay. In the Upper Carboniferous formation a quarry was opened some years ago at Wood Point, below Sackville, which, from the lay of the rock and the color, promised excellently, and a large amount of money was spent in developing. The presence of small pebbles of soft red shale, however, was found to be so prejudicial as to affect the value very seriously, and the quarry is now closed.* The color of the stone in the Millstone-grit area varies from grey to brown, and at some of the quarries blocks of any required size can be obtained.

In Cumberland county, N.S., quarries of building stone are found, principally in what is regarded as the upper formation on the Wallace River and at several places along the north shore, from Tidnish Head eastward. The stone is both brown and grey, and generally of excellent quality. Fine quarries also have been worked in the Millstone-grit near the Intercolonial, in the vicinity of River Philip, and also at Claremont Hill. A beautiful series of reptilian footprints was obtained from the slabs at these quarries some years ago.

The building of the Intercolonial caused many quarries to be opened in this section of the country, some of which yielded a very excellent building stone. Many of these have, since the completion of the line, been closed, the cost of transport being against the profitable shipment of the stone, though some of them are still worked to a limited extent on local orders.

Grindstones.—These are manufactured in large quantity, principally Grindstones.

* Recently re-opened, 1885.

on the Joggins shore, at the Lower or Seaman's Cove quarries. The cutting and turning machinery here is driven by a steam engine, and the output for the last year was—of grindstones 2,000 tons, and of scythe stones 2,000 boxes, valued at $28,400. Other areas, where grindstones are made, are the southern extremity of Cape Maringouin, Port Philip, and several places along the Joggins shore, south of the Joggins mines. No returns have been obtained from any of these places, though the totals must be considerable.

Petroleum.

Petroleum.—Large sums of money have been spent in the area between the Petitcodiac and Memramcook Rivers during the last few years in a vain attempt to obtain oil in quantity. The operations have been confined to the belt of Albert shales and associated bituminous sandstones, and the bore holes have in some places reached a depth of not far from 2,000 feet. Reliable records could not be obtained of the several bores, but oil was obtained only in very small quantity.

Albertite.

Albertite.—Since 1876, operations have been carried on from time to time by shafting and boring for the purpose of finding deposits of this mineral at points other than at the Albert mine. Large sums of money have been spent, at times very foolishly, but no deposits have yet been found, except as mere traces. Though the shales in which the albertite occurs have a very extensive development (see Report of Progress, 1876–7), the peculiar conditions found at the Albert mine, by which the great vein at that point was formed, have not been recognized elsewhere. Numerous faults occur at other places, but there are only small strings of Albertite and nothing more.

The exhaustion of the great vein at the Albert mine, several years ago, closed one of the most profitable mining enterprises of the Dominion. The wedge-like character of the deposit, which was a true fissure, was well illustrated in the lower levels, the vein gradually decreasing downward, as well as at both extremities, to four inches, beyond which, becoming unprofitable, it was abandoned.

Infusorial earth.

Infusorial earth was discovered in several lakes in New Brunswick some years ago and the localities indicated in former reports. In Nova Scotia, although occurring at different points, perhaps the largest, certainly the largest yet known, is found to occupy the bed and shores of

Folly Lake.

Folly Lake on the Intercolonial railway, just at the summit over the Cobequid Mountains. This lake has an area of over 200 acres, the two-thirds of which are probably covered with this deposit. The quality is excellent, and considering the variety of uses to which this material can be applied, it seems strange that no attempt has yet been made towards the development of these localities. The earth is specially adapted for the manufacture of boiler and steam-pipe coverings, fire brick, tiles, &c., being a perfect non-conductor of heat.

It is also largely used for the manufacture of water glass (soluble silicate of soda) and in the manufacture of dynamite, as well as an absorbent in the preparation of fish manures. Being a perfect non-conductor, it would seem to be specially adapted for the packing of safes, and should its non-conductivity as regards electricity be equal to that in regard to heat, its value would be greatly increased as an insulating medium in the underground laying of telegraph wires. The action of the material in this respect has, in so far as I can learn, not yet been ascertained.

Lately, a very valuable deposit of this earth has been found by Mr. David Grant, occupying the bed of Fountain Lake, on the road to River Philip (West Chester Mountain). It is of remarkable purity and in large quantity, and the lake is said to be easy to drain. It is about eight miles distant from the Minas Basin at Port-au-Pic, and the same distance from the Intercolonial railway. Other deposits of greater or less extent occur in the numerous lakes of this mountain region.

Fountain Lake

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA

ALFRED R. C. SELWYN, LL.D., F.R.S., F.G.S., DIRECTOR.

REPORT

OF

EXPLORATIONS AND SURVEYS

IN PORTIONS OF THE

COUNTIES OF CARLETON, VICTORIA, YORK AND NORTHUMBERLAND, NEW BRUNSWICK.

1885.

BY L. W. BAILEY, M.A., Ph.D., F.R.S.C.,

PROFESSOR OF NATURAL HISTORY IN THE UNIVERSITY OF NEW BRUNSWICK.

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1886.

A. R. C. SELWYN, ESQ., LL.D., F.R.S., &c.,

Director of the Geological and Natural History Survey of Canada.

SIR,

I beg to submit herewith a report of geological investigations made, in accordance with your instructions, chiefly during the summer of 1884, in portions of northern and western New Brunswick.

In addition to my own observations, the report embraces those of my assistants, Mr. Wm. McInnes and Mr. J. W. Bailey, who have also constructed the accompanying map. In this map an attempt has been made to represent the orographic as well as the geological features. It forms Sheet No. 2 S. W. of the general geological map of the province. My acknowledgements are again due to the manager of the New Brunswick Railway Company for facilities afforded both to myself and my assistants; as well as to the officers of the Crown Lands Department in Fredericton.

I have the honour to be,

Sir,

Your obedient servant,

L. W. BAILEY.

FREDERICTON, January 11, 1886.

REPORT

OF

EXPLORATIONS AND SURVEYS

IN

PORTIONS OF THE COUNTIES OF CARLETON, VICTORIA, YORK AND NORTHUMBERLAND,

NEW BRUNSWICK.

Region described.

The region to which this report relates includes portions of the counties of Carleton, Victoria, York and Northumberland. It lies immediately north of that described in the Report of Progress for 1883, and forms a parallelogram, of which the western and the eastern borders are respectively marked in a general way by the boundary of the State of Maine, and a north-and-south line cutting the Miramichi River about eight miles below Boiestown; while the southern border is an east-and-west line crossing the St. John River two and a-half miles above Woodstock, and the northern border a similar line intersecting the same river four miles north of Aroostook junction. Owing to the approximation of the St. John River to the United States frontier, north of Woodstock, the portion of the area lying to the westward of that stream forms but an inconsiderable part of the whole. It is, however, its most populous portion, the settlements east of the river being comparatively few, while over a large part of the district examined the country is still in unbroken forest.

Topographical features.

Topographically, the region is one of much diversity. Portions of it, more particularly on the western side of the St. John River, though by no means low, are comparatively flat or gently undulating; but in general the surface is broken by numerous ridges, varying in elevation from 500 to 1,200 feet above the sea level, while between these, the valleys, though sometimes broad and open, are often remarkable for their depth and their abruptness. These depressions are usually occupied by water-courses of greater or less size, and within the district are included, wholly or partly, such important streams as the Tobique, the South-west Miramichi, the Beccaguimic, the Aroostook, the Nashwaak and the Presque Isle. The usual course of the hill ranges is

between N 20° E and N 25° E,* becoming in the northern portion more nearly north and south, but these courses would seem to have had but little influence in determining that of the streams and rivers, which not unfrequently intersect the hill ranges obliquely or even at right angles. In such cases it is usual to find the passage accompanied by more or less considerable rapids or falls, as illustrated in the Grand Falls of the St. John river (74 feet), the Aroostook Falls and the Narrows of the Tobique. Lakes are comparatively few and of small extent.

Elevations.

The following table of elevations above sea level, based on barometric observations, made chiefly by Mr. J. W. Bailey, but including also a few as determined by Mr. Chalmers and the Boundary Commission, is intended as supplementary to the hill sketching as represented upon the map:—

	FEET.
Moose Mountain	1,030
Hill on Shiktehawk, north of Glassville Centre	1,255
Ridge north of West Glassville	785
Ridge on Shiktehawk, south of Johnville Road	795
Hill, ¼ of a mile south of Gordonville Post-office	995
Glassville Centre	790
Johnville Church	640
Height of land between Pokiok Bridge on Tobique River and Little River	650
Hill on Stickney Brook, 2 miles east of St. John River	900
Nashwaak Mountain, on South Branch of Miramichi	855
Height of land between Foreston and McEwen's on S.W. Miramichi	900
Between Foreston and Smith's Corner	875
Hill at Argyle Corner	1,135
Ridge opposite Andover	590
Hill, 1¾ miles below Andover, 1¾ miles back from St. John River	800
Height of land 3 miles back from Tobique River on Red Rapid settlement road	1,190
Mars Hill	1,688

The character of the soils and the agricultural capabilities of the region vary with the nature of the rock formations which occupy its several portions. Some remarks upon these subjects will be found in connection with the descriptions of the latter given below, but as they have been made the subject of special examination by Mr. R. Chalmers, it has not been thought necessary to give them extended consideration here.

* These, and all other courses given in this report, are with reference to the true meridian. The variation is about 20° W.

Geologically the region is found to embrace the following systems and divisions :—

Geological formations.

G. Carboniferous.
 (a) Middle Carboniferous (Millstone Grit.)
 (b) Lower Carboniferous.
F. Devonian.
E. Silurian.
D. Cambro-Silurian.
A. B. Pre-Cambrian.
Crystalline rocks, including granite.

G. Carboniferous.

General distribution.

The Carboniferous rocks in the district examined are of comparatively limited extent, and are comprised in three areas, of which one includes a portion of the valley of the Tobique, a second, a part of the district traversed by the Beccaguimic and its tributaries, and the third, portions of north-eastern York county, between Stanley and the Miramichi River.

Tobique area.

The Tobique area was somewhat closely examined by Prof. H. Y. Hind in 1865 and again by Mr. Charles Robb in 1868, and in the reports of these gentlemen the more important facts as to its extent and character are given. The present examination has been chiefly directed to a more accurate limitation of its boundaries, effected by ascending and measuring the several streams—the Gulquac, the Odell and Odelloch—which are tributary to the Tobique from the southern side. These measurements, made by Mr. McInnes, give this Carboniferous area a somewhat increased breadth as compared with previous representations. Its southern margin is near the head-waters of the streams named, and distant, at the widest part, about nine miles from the main valley of the Tobique. The total breadth of the area would thus be about twelve miles, and its length, from the Red Rapids to Blue Mountain, about twenty-seven miles.

Limits.

Succession of rocks.

The rocks appear to belong wholly to the lower or marine division of the Carboniferous system, and as seen along the course of the Tobique, present a succession of low undulations, the dip rarely rising higher than 4° or 5°. The following is a summary of their main sub-divisions in descending order :—

Trappean beds, consisting of grey amygdaloidal dolerite.

Heavy beds of impure gypsum, of pale-green and reddish colours, mostly fibrous but sometimes compact, alternating with thin beds of red shale. Thickness about 350 feet.

Red, grey and green shaly and marly beds, with thin beds of fine-grained grey, red or mottled limestone. Thickness 140 feet.

White, red and variegated calcareous sandstones and grits.

Red and grey conglomerates and sandstones, the former holding pebbles of Silurian slates.

The above succession is, in its main features, similar to that of the Lower Carboniferous formation as seen in Kings, Albert and Westmoreland counties.

The remarkable fertility of this Carboniferous area is attested by the character and the luxuriant growth of its indigenous vegetation, and had attracted attention long before any attempts were made to occupy it for settlement. Now, its fertility and value are fully recognized, and since it has been brought into closer connection with outside markets by the extension of the New Brunswick railway, it has shewn a constant and rapid growth in population and productiveness.

The Carboniferous area of the Beccaguimic is considerably smaller as well as more irregular than that of the Tobique. It also presents a somewhat different succession of rocks.

Beccaguimic area.

Its general form may be described as broadly triangular, with rounded angles and somewhat sinuous and interrupted margins. Two of these margins are coincident, or nearly so, with the two main branches of the Beccaguimic River, but west of the confluence of these streams the area extends to within a few miles of the St. John, where it was probably at one time connected with similar but smaller Carboniferous areas or outliers, occurring along the course of that stream.

Limits.

The highest rocks found in this district are included in the nearly elliptical area embraced by the two streams referred to above. They consist of a series of coarse, grey sandstones, associated with olive-grey freestones, both of which contain vegetable impressions in the form of broken stems. These are too imperfectly preserved to be identified, but the character and relations of the strata leave no doubt that the horizon is that of the millstone grit or base of the Middle Carboniferous. They dip uniformly at a low angle and their surface is consequently nearly flat, but where cut away by the valley of the South Branch they present towards the latter a bold escarpment, (nearly 400 feet in elevation) forming a prominent feature in the landscape. Portions of the flat thus formed are well wooded, but towards its eastern limit it is largely occupied by barrens and small lakes.

Middle Carboniferous.

While the elliptical area above described, which forms the higher portion of the district, is thus occupied by Middle Carboniferous rocks, the deep valleys traversed by the main branches of the Beccaguimic dis-

close to view other and more ancient strata. These are described below and are in part of Silurian and Cambro-Silurian age, but resting upon the last-named rocks unconformably, and forming several small areas more or less disconnected, is also a series of beds the character and position of which sufficiently show that they are the representatives of the Lower Carboniferous formation. As seen along the valley of the North Branch, at and below Shaw's mill, they are mostly conglomerates of a coarse character, filled with large well-rounded pebbles of the underlying rocks, and possessing a brownish-red colour. Similar conglomerates occur also near the bridge above the Howard brooks, where they form conspicuous and precipitous hills with an elevation, above the valley, of about 300 feet. Still farther up, in the same valley, the highest beds seen are bright red and purple—sometimes mottled—sandstones and shales; but towards the head of the branch, the red rocks are seen to rest upon and apparently to graduate downwards into red somewhat earthy felsites, associated with grey felspathic or doleritic sandstones. These felsites are similar in character to those which occur at Harvey settlement and elsewhere around the border of the central Carboniferous area of the province, and are probably of contemporary origin. Excluding the felsites and associated trappean beds, the dip of the Lower Carboniferous sediments in this valley, like that of the coal measures, is usually low, varying from 5° to 20°. In some of the felspathic sandstones, however, as observed by Mr. Matthew, the dip is as high as 60°.

Lower Carboniferous rocks.

Trappean beds.

Owing to the thickly wooded character of most of the region adjoining the Beccaguimic and its branches, and the consequent infrequency of exposures, the determination of the nature of the underlying rocks is often a matter of much difficulty, and their boundaries are necessarily somewhat conjectural. Lower Carboniferous sediments, however, in the form of red marls and sandstones, occur along the larger part of the North Branch valley, and again along that of the South Branch, as far as its North Fork near Hamilton brook. The extreme limit of the Carboniferous triangle in this direction is probably about one mile west of South Branch Lake, and but little more from the south-western end of the great granite belt of York and Carleton. Carboniferous rocks also occupy, as has been before stated, a considerable area between the point of confluence of the branches of the Beccaguimic and the St. John River, being well exposed about the summit of the eminence known as Pole Hill, and again in the cuttings along the old track of the New Brunswick railway where this crosses the valley of the Little Pokiok stream. At Pole Hill, the rocks are red and grey conglomerates, resting, with a low dip, on highly tilted Silurian slates.

Pole hill.

At the head of the Little Pokiok they are mostly of a finer character, embracing chiefly sandstones and shales of red and maroon colours and containing vegetable impressions. Their dip is also higher, rising to 40° or 45°.

In addition to these Carboniferous strata on the eastern side of the St. John, in Carleton county, one or two small areas, which are believed to be of similar age, are found upon the western side of the same stream, and mark a former extension of the Carboniferous basin in that direction. They are, however, confined to the immediate vicinity of the river, where they appear in the form of long, narrow belts, capping the hills and in part skirting the shore, between Upper Woodstock and Victoria corners. The rocks composing these belts are mostly coarse conglomerates, of a deep brownish-red colour, and often stained with manganese. They include, however, some finer beds. Their dip, like that of the beds on the upper parts of the Little Pokiok, is comparatively high, sometimes as much as 50° or 60°, but varies considerably, and is at all times much less than that of the Silurian slates, upon the upturned edges of which they may at various points be seen to rest.

Upper Woodstock.

F. Devonian (?)

In the description of the Lower Carboniferous of the Beccaguimic region, this age, as being that of the bulk of the sediments there met with, has been assumed, not only on the ground of their evident resemblance in colour, texture and composition, to the rocks of the same age in other parts of the province, but from their equally evident unconformity to the associated rocks, their usually low inclination, and their passage upwards into the ordinary rocks of the coal-measures. Accompanying, however, these Lower Carboniferous deposits, and not always to be easily distinguished from them, there are, in the same region, some other beds in which the relations are less evident, and which have been thought to indicate the presence of Devonian as well as Lower Carboniferous sediments in this portion of Carleton county.

Supposed Devonian rocks

The rocks in question are best exposed at the mouth of Little Pokiok brook, about two miles below Hartland, where their occurrence was first noticed by Mr. Chas. Robb. In texture and composition they are, for the most part, not unlike portions of the Lower Carboniferous rocks, consisting of coarse grey conglomerates, holding large, well-rounded pebbles, chiefly of Cambro-Silurian rocks; but interstratified with these are a few thin beds of finer character, some of which are black and glossy with carbonaceous material, and others are filled with impres-

sions of plants. These latter were determined by Sir Wm. Dawson, in 1871, as being the remains of *Psilophyton princeps*, and it was from their occurrence here that not only the beds more immediately containing them, but all the newer sediments of the Beccaguimic basin were supposed to be of Devonian origin, and regarded as the equivalents of the Gaspé sandstone of the province of Quebec. While, however, this latter view, for reasons above given, is now regarded as untenable, it does seem altogether probable that these plant-bearing strata, together with the conglomerates which enclose them, are of pre-Carboniferous origin, and did they stand alone, might well be regarded as of Devonian age. It is not, however, by any means so certain that they are not really in part pre-Devonian as well as pre-Carboniferous, and form a portion of the Silurian system elsewhere so prominently developed in the neighborhood. Unfortunately, there is nothing either in the character, position or fossils of these beds, at the locality in question, by which this point can be definitely settled. A strong confirmation, however, of the view that they are really Silurian is to be found in the occurrence of very similar remains on the north-east branch of the Beccaguimic, not only in rocks presenting quite a different aspect from those of the Little Pokiok, but among beds of which a portion at least are certainly of this latter age.

Fossils.

Probably Silurian.

These beds occur on the left bank of the stream, about half a mile above Shaw's mill, and consist of dark-grey slaty sandstones or grits, having their surfaces covered with numerous linear and dichotomously branching stems, many of which are longitudinally furrowed and marked by rows of rounded knobs or depressions indicating the attachment of leaves. The associated rocks are rubbly, grey quartzites, which are felspathic and concretionary, and partly dark flinty slates, but their relations are greatly obscured by faults as well as by the smallness of the exposures, and no definite conclusion could be formed regarding them.

E. SILURIAN.

The existence of Silurian (or as then called Upper Silurian) rocks in northern New Brunswick was first announced by Dr. A. Gesner in 1843, organic remains indicative of this horizon having been found by him at various localities in the county of Restigouche, as well as along the valley of the St. John River, in what are now the counties of Carleton, Victoria and Madawaska. This conclusion has since been confirmed, as regards the general character of the district, by the observations of various explorers, among whom may be mentioned, Dr. James Robb, Prof. C. H. Hitchcock, Sir W. E. Logan, Prof. H. Y. Hind, Mr.

Earlier investigations.

Chas Robb, and Mr. R. W. Ells. In the reports of all these gentlemen will be found much valuable information relating to the geological or other features of the region described, while that of Mr. Ells, published in the Report of Progress for 1874-75, is accompanied by a geological map, illustrating particularly the distribution of the iron ores of Carleton county. It was not, however, until the year 1880, that by simultaneous observations made by Mr. G. F. Matthew, on the eastern side of the St. John River, in the Beccaguimic region, and by the writer on the western side of the same stream, a definite physical and geological boundary of the formation was ascertained, and its relations to the other systems clearly established. These relations, as regards the section west of the St. John, from Woodstock to the Maine frontier, are described in the Report of Progress for 1882-84. Those of the eastern section, as made by Mr. Matthew, have also formed the subject of a special report, but as the district to which this relates has since been carefully re-examined and the strata there met with traced and studied over considerably wider areas, the results then obtained are, by permission, here embodied with those of the later and more extended observations.

Area of Silurian.

The area of Silurian rocks to which this report relates is a very large one. West of the St. John River (where its southern border was described, last year, as extending from Victoria corners, nine miles above Woodstock, to the frontier, at Bull Creek in South Richmond,) the entire area between the river and the boundary, northward to the Grand Falls, is thus occupied. On the eastern side, the same southern border may be described as commencing at Deep Creek, two miles below Hartland, thence extending, north of Pole Hill, to the Beccaguimic River and its tributary, the North-east Branch, up the latter to the Howard brooks, and thence, by a nearly northerly course, through Skedaddle Ridge, to the settlement of Beaufort; beyond which, in the same direction, it is continuous to the eastern edge of the Tobique Carboniferous outlier already described. The country in this direction being thickly wooded, with few exposures, the exact limitation of formations is impossible, but the lines, as laid down, accord with such information as we have been able to obtain. Excepting the outlier referred to, the whole district north and west of the line described, is believed to be referable to the Silurian system.

Physical features.

The physical features of this extensive area present, as might be expected, considerable diversity, and are worthy of remark from their bearing on the causes which have originated them as well as upon their relations to the agricultural capacity of the district. Speaking broadly, the Silurian area may be described as forming a moderately elevated plateau, having a mean height above the sea level of about 500 or 600 feet. In its western portion the plateau

is intersected through its entire extent, and in a general north-and-south direction, by the deep valley of the St. John, but as the sections thus made are of very unequal extent, so they also present many features of contrast as regards their orographical aspects. Thus, on the western side of the river, from Woodstock northward, at least as far as the boundary of Victoria county, and westward to the Maine frontier, the country, though far from being low or flat, is nowhere hilly, presenting rather a series of gentle undulations, with a drainage embracing numerous but mostly small streams, and not unfrequently diversified by small lakes. On the eastern side, on the contrary, hills and ridges are met with in almost every direction, these often attaining an elevation of over 1,000 feet, while the separating valleys are deep and not unfrequently abrupt, giving passage to such streams as the Beccaguimic* and the Shiktehawk, the Munquart and the Tobique. In most instances these ridges are composed of the same slates as those which occupy the intervening lowlands, and no very obvious connection can be traced between their occurrence and either the composition or structure of the rocks accompanying them. Occasionally, however, where these are of an eruptive character, as in Moose Mountain, (an eminence which, near the boundary between Carleton and Victoria, rises abruptly, from a comparatively level tract to a height of 1,030 feet), it is evidently to the hardness of their constituent minerals and consequent power of resistance that their prominence is to be ascribed. The general course of the slate ridges, like that of the formations composing them, is about N. 10°—20° E.

In the study of the geology of the Silurian district two main difficulties are to be contended with. Of these, one arises from the comparatively slight diversity in the nature of the rocks to be studied, which, as a consequence, present nearly the same aspect over wide areas, and the second, from the profound disturbances which they have everywhere undergone. It is thus well-nigh impossible to determine with anything like certainty, either the order of succession or the relative or total thickness of the several subdivisions of the system. Some aid, however, in this direction is afforded by the organic remains found at different points, as well as by the occurrence of ore deposits, and again by the occasional presence of conglomerates apparently marking the base of the system. From a careful study of these data we have been led to regard the following as representing their probable arrangement, the succession being a descending one:— Difficulties.

* In the case of the first named of these streams, a good illustration is afforded, not only of the extent but of the irregularity of the erosive processes by which these valleys have been formed, its serpentine course being such as to more than double the actual distance between its source and outlet.

Probable succession.

Grey, or greenish-grey (bluish weathering) argillites, with occasional alternating beds of greenish-grey sandstone.

Grey, green and bright-red slates, holding heavy beds of manganiferous hæmatite.

Grey, highly calcareous slates, conspicuously banded on weathered surfaces, and including at various points heavy beds of limestone, which are more or less fossiliferous.

Grey, calcareous and buff-weathering sandstones and slates, holding remains of crinoides, corals, brachiopods and graptolites.

Grey, calcareous conglomerates and sandstone, holding pebbles of Cambro-Silurian rocks.

A description of the argillites which mark the base of the Silurian and their relations to the underlying Cambro-Silurian system, as seen on the western side of the St. John River, is contained in last year's report. It is, however, on the eastern side of the same river, and more particularly about the branches of the Beccaguimic, that their relations, as well as those of the higher beds, are most clearly seen. It has been already stated that considerable portions of the valleys occupied by these streams, as well as the higher lands which they include, are composed of Carboniferous sediments, but in cutting their way down through the latter, the water-courses in question have also exposed beds of considerably greater antiquity. The best exposures are to be found on the North-west Branch, above Shaw's mill. At the mill dam itself may be seen a few ledges of very hard, dark-grey silicious slate, having a nearly vertical dip, and capped by nearly flat, brownish-red and rusty-weathering conglomerates, through which ridges of the slate project irregularly. The greater part of these conglomerates have the aspect of Lower Carboniferous sediments, and are apparently continuous with the strata of this age seen further down the valley, but some appear to be older, while the occurrence—a short distance up the stream already noticed—of beds holding the remains of *Psilophyton*, render it probable that both are a repetition of the very similar strata at the mouth of the Little Pokiok. The silicious slates, which again appear beneath the plant-bearing beds, as well as at various points between Shaw's and Campbell's mills, are, as will presently appear, of Cambro-Silurian age. In the hills, however, which overlook the valley on the west, and again along the course of the branch above the mill last named, are other beds which, both by their character and their fossils, shew that they belong to the Silurian system. Among these strata are the grey conglomerates or grits, which, according to the tabular view above given, are regarded as forming the base of the Silurian succession. They are largely made

Unconformity.

Basal conglomerates.

up of fragments of black, silicious slate and grey quartzite, such as might be derived from the Cambro-Silurian strata near by, imbedded in a grey, calcareous paste, of which portions, as observed by Mr. Matthew, seem to be largely made up of crinoidal fragments. They are also further distinguished from the Lower Carboniferous conglomerates which accompany them by their conformity to the trend of the Silurian system, by their much higher inclination, and in the finer beds, by a slaty cleavage not usually met with in the first-named formation. But the most interesting strata to be found in this vicinity are those which, as is believed, come immediately above these conglomerates in the Silurian succession, and which consist of a series of slates and sandstones abounding in organic remains. The discovery of fossils at this point was first made by Mr. G. F. Matthew in 1880, **Fossils.** who also recognized the existence here of two distinct and unconformable formations, but more recent and extended examinations, as well as more ample collections of fossils, have led to the inference that portions of the beds regarded by Mr. Matthew as Cambro-Silurian are really a portion of the overlying Silurian. The rocks in question are first met with, in ascending the stream, near the head of the mill pond above Campbell's mill, and consist of rubbly and somewhat micaceous sand- **Campbell's mills.** stones or sandy slates, which in places hold pebbles of grey quartzite, and have a westerly dip at an angle of about 80°. Their colour in some parts is grey or dark grey, but more commonly purple or chocolate-brown, and their aspect often not unlike that of Lower Carboniferous sediments; but, apart from the extensive plications which they have undergone and the slaty cleavage by which this is accompanied, the occurrence here and there of such fossils as Orthocerata, Trilobites, **Fossils.** crinoids and shells, mingled with the remains of plants, leaves no doubt as to the much greater antiquity of the beds containing them. This is further indicated by the occurrence, a little higher up the stream, but in beds which are evidently part of the same series, of the abundant remains of Graptolites. Unfortunately, the majority of these fossils are too fragmentary for specific determination, but their general *facies* is certainly that of the Silurian system, while the comparison of the containing rocks with those met with elsewhere leaves little doubt as to their true position. As regards the graptolites, which are better preserved than the accompanying remains, Mr. Whiteaves furnishes the following note:—

"*Monograptus* sp. This form belongs to a group of monoprionidian graptolites, comprising such related forms as *M. priodon* Bronn. and *M. lobuliferus* McCoy. Mr. Ami thinks that it may possibly be identical with *M. Sedgwickii* (the *Graptolithus Sedgwickii* of Portlock),

but the specimens have not yet been studied sufficiently to enable a confident opinion to be given on their specific relations.

"In Europe the genus *Monograptus*, of Geinitz, is regarded as exclusively of Silurian, as opposed to Cambro-Silurian age, and in Canada and the United States ranges as low as the Clinton formation, of which one of the species (*M. Clintonensis*, Hall, sp.) is very characteristic.

"On this evidence it would appear that the rocks in question belong to the Silurian system, as recently restricted in the publications of the Survey."

No other Silurian rocks than those above described are to be found in the North Branch valley, (the last beds visible being the basal conglomerates which, at the bridge above the Howard brooks, pass beneath the Lower Carboniferous outlier), but a few miles to the westward, in Windsor, as well as at various points in the intervening area, facts may be observed which tend to throw further light upon the Silurian succession. The most interesting beds to be found in this interval are undoubtedly the great deposits of limestone which have long formed an important source of lime-supply for all this portion of Carleton county. They are somewhat irregularly distributed, and, owing to the thickly wooded character of the country, rather difficult to trace. They seem, however, to occupy the position of one or more tolerably well defined belts, having a general north-east course, parallel to the border of the Silurian area, and extending from the St. John River near Hartland through the larger part of the parish of Brighton. There are, on the St. John, no workable deposits of limestone, but it is probable that this portion of the system is there represented by the beautifully banded or ribbanded beds which form the western shore at and below Hartland ferry, and which are so highly calcareous as to have led to unsuccessful attempts at their calcination. It was also stated, in the report of last year, that limestones, which have been worked to some extent, are found in what may be regarded as a continuation of the same belt, at Ivy's corner, twenty miles to the south-west, in the parish of Richmond. The largest as well as the purest of these deposits, however, are those which are to be found in the region about the upper waters of the Beccaguimic and its tributaries. One of these deposits, known as Gulliver's, is found at the head of Limestone brook, about a mile and a-half north-west of Pole Hill, but is not now worked. The limestones, which are but a few feet in thickness, occur in slates dipping W $<$ 40°, and in both rocks, remains of shells, crinoids and other organisms may be found, but mostly in a bad state of preservation. The next deposits to the eastward, and the most important of all, are those known as Turner's, which are found on the descent of the hill leading down to the North Branch valley about,

Windsor.

Limestones.

half a mile below Shaw's mill. Two quarries have been here opened, in one of which the thickness of the beds exposed is about 30 feet, while in the other, situated about 120 rods to the north, this is increased to about 100 feet, the rock being a compact bluish-grey limestone, with sparry veins and pockets. From both, considerable quantities of rock have been removed, further particulars of which will be found in the sequel. The course of the beds varies from N 30° E at the old, to N 5° E at the new quarry, and their attitude is nearly vertical. We were not able to find any fossils in the limestones, but the beds which accompany them, in the form of buff-weathering sandstones, are evidently, in part at least, a continuation of those already described as occurring along the course of the North-east Branch, and, as in the latter, were found to contain the stems of crinoids, as well as the shell of a large *Orthoceratite*. The course of the beds at Turner's, already given, as well as that at Gulliver's, would indicate an extension of this belt in the direction of the Howard brooks and Skedaddle Ridge, and the accompanying rocks, in the form of grey grits, are actually met with in that direction, but from what is seen a few miles to the northwest, in Henderson settlement, it would appear that there is here a second belt, or, what is more probable, a repetition of the first, by folding or faulting. One bed of limestone belonging to this belt has been recently exposed on the north side of a high hill, around the flanks of which passes the road to Henderson's corner; but other and more considerable beds are to be seen close by the corner itself, where they have been and still are somewhat extensively worked. Their surface breadth at this point is about 200 feet, and their course about N 20° W, while the dips are variable and not easily distinguished. At both localities they are accompanied by grey buff-weathering sandstones or sandy slates, in every way similar to those of the North-east Branch, and at Henderson's these slates, as well as the limestones, are again fossiliferous, containing numerous joints of crinoidal stems, and, more rarely, remains of brachiopods, gasteropods, trilobites and branching corals, but mostly in a fragmentary condition. Among the forms collected by us Mr. Whiteaves has recognized *Pentamerus galeatus*, Dalman, and a *Dalmanites* (sp. indt.) both belonging to the Silurian system, while Mr. Matthew previously obtained from the same locality small individuals of *Atrypa reticularis* and *Strophomena depressa* or allied forms, besides remains of graptolites. At both localities also, as well as in the interval between them, may be seen masses of grit and conglomerate in every way similar to those already described as occurring near Shaw's mills and near the Howard Brooks on the North-east Branch. Like the latter they are conspicuously filled with fragments of black petrosilex and alternate with thin beds of dark

Turner's lime-beds.

Lime-beds.

Henderson's lime-beds.

Fossils.

Conglomerates.

grey slate and sandstone, the whole having a surface breadth of about twenty-five chains, with a nearly vertical dip, and a course about north. In this same direction, but at a distance of six or eight miles, similar beds have been observed crossing the road leading north from the settlement of Knowlesville. It is noticeable that these conglomerates in many respects are not unlike those which, at the mouth of the Little Pokiok, contain remains of *Psilophyton* and have been regarded as Devonian. There can be but little doubt, however, that those here considered are a portion of the Silurian system.

It has been stated that the limestones of Windsor (Henderson's) are probably a repetition by folding of those upon the Beccaguimic, and as the whole Silurian tract is one of highly disturbed and plicated strata, the reappearance of these beds at still other points to the north is no more than might naturally be expected. While, however, very highly calcareous strata, which nearly resemble those associated with the last-named limestones, occur at a number of points in northern Carleton and in Victoria county, and in several instances have been described as limestones, no beds sufficiently pure to be so called have been anywhere met with by us. In the admirable section afforded by the St. John River, beds of this character are well exposed at the following points, viz.:—along the eastern shore near the mouth of the Shiktehawk, a few miles further up (on the west bank) opposite Bath, at the mouth of the Munquart, at the mouth of the Mániac, about Andover and in the Narrows of the Tobique, and finally in the gorges of the Aroostook and Grand Falls;—they being, in each instance, portions of belts which appear to extend with approximate parallelism and with generally northerly or north-easterly courses, over much of the surrounding country. Like the beds below Hartland ferry, already described, they may usually be recognized, even at a distance, by their conspicuous banding or ribanding, the result both of the different hardness and the different weathering of the calcareous layers, often very delicate, of which they are composed. They are often, also, filled with sparry veins, and it is for the burning of material collected from the latter that most of the small kilns found scattered over the country, but now abandoned, have been erected. We have not been able to find any fossils in these more highly calcareous beds, but in the associated slates and sandstones they are not uncommon, and have been observed at a number of points. Some of these are mentioned in the reports of Dr. Gesner. The best localities, however, with which we are acquainted, are found on the bank of the St. John River, in Perth (just opposite the upper end of the town of Andover), and on the Tobique River, half a mile above the head of the Narrows. The beds on the Tobique are

Calcareous beds.

Fossils in Perth

somewhat more sandy than those on the main river, but the fossils at the two points are very much the same, and as the distance between them is not great (not over two miles), it is not unlikely, notwithstanding a slight difference of strike, that the strata of the two places are continuous. They are especially remarkable for the number of large corals which they contain, the names of which, with other forms, are given in the following list, as determined by Mr. Ami, under Mr. Whiteaves' supervision :—

> *Halysites catenulatus*, Linn.; small variety resembling one from Baie des Chaleurs.
>
> *Favosites Gothlandica.*
>
> *Heliolites.* sp. indt.
>
> *Syringopora.* sp. indt.
>
> *Cyathophyllum Pennanti*, Billings. [There appear to be connecting processes between the corallites, as in the above species, and a small inner area, through which the radiating lamellæ do *not* enter, thus resembling the structure of *Diphyphyllum*, Lam.]
>
> *Rhynchonella*—allied to *R. Wilsoni.* Sby.
>
> *Murchisonia.* sp.
>
> *Atrypa reticularis.*
>
> "The horizon of the above is probably not higher than the Lower Helderberg, nor lower than the Niagara."

In the case of the Silurian beds so far noticed, considerable assistance towards their recognition has been afforded either by their lithological characters or by their contained fossils. The same is to some extent true of the beds which are now to be noticed, which contain the great deposits of iron ore in Carleton county; for although these, so far as known, do not contain any organic remains and are somewhat variable in their distribution, yet they are such, as both by their colour and other characteristics, to readily attract attention. Like the majority of the Silurian strata they are slates, and are also more or less calcareous, but are not conspicuously so, while the grey or dark-grey colour, elsewhere so prevalent, is here, in part at least, replaced by greenish, brownish-red or in some instances blood-red colours, associated not unfrequently with black superficial coatings of manganese. The distribution of the ore deposits has been pretty thoroughly worked out by Mr. R. W. Ells in 1874, and in his report for that year will also be found many interesting facts relative to their character and work- **Iron-bearing beds.**

ing. To these I have only to add that, so far as I have been able to ascertain, there are, on the eastern side of the river, no deposits which either in extent or value will at all compare with those which have been opened and used west of the river, in Jacksontown. The few additional points at which they have been observed by us will be found indicated in the geological map accompanying this report. It may be added that, while along particular belts, many distinct beds undoubtedly exist, varying from a few inches up to twenty feet in thickness, there is also a recurrence of the belts as a whole along parallel but somewhat widely separated tracts. They thus afford another illustration of the repetition, by folding, which characterizes the entire Silurian area. One such belt, but of little importance, is indicated by scattered observations as extending from near Hartland, on the St. John River, to the mouth of the Coldstream, a branch of the Beccaguimic, and some beds containing hæmatite, observed by Mr. Ells and others near Glassville, may be a continuation of the same; though it is quite probable that these may belong to the next and principal belt, viz., that of Jacksontown, from which the so-called "Woodstock ore" was derived, and which is directly traceable from near Belleville, in the valley of the Meduxnakeag, to Flannigan's Hill on the St. John River. Among the blood-red slates which occur at this point, some were found to contain numerous large but badly preserved casts of shells, while in accompanying grey slates and sandstones were found remains of an *Alveolites*, together with many fragments of crinoids. Fossils were first obtained from this locality by Dr. Gesner. On the eastern side of the river this belt is probably represented, in part at least, by high ridges (800 feet by aneroid) about the sources of Stickney brook, and fragments of the red slate were observed in the hills just south of the Shiktehawk road, midway between Kent station and Gordonville; but the beds exposed on the road are mostly dark blue slates, associated, however, near the settlement last named, with peculiar beds of conglomerate and sandstone. These are referred to, in Prof. Hinds' report to the provincial government, as marking the base and lower limit of the Silurian system in Carleton; but in addition to the fact, as already shown, that the real boundary of the system is situated very much farther to the south, these conglomerates present a somewhat different aspect from those of the Beccaguimic, and are unaccompanied by any evidences by which their true position can be determined. They contain pebbles of slate, quartzite, white quartz and black petrosilex, together with numerous white quartz veins, and are interstratified both with slates and sandstones, the whole dipping N. 65 W. $<$ 60°.

Iron-ore belts.

Fossils.

Conglomerate of Shiktehawk.

No other belt of iron-bearing strata has been observed within the limits to which this report relates, but it may be worth while to notice

that another band of precisely similar character extends across the head-waters of the Aroostook, in the State of Maine, and probably approaches the provincial boundary between the latter and the Grand Falls, but, from the infrequency of exposures in this section, it has been impossible to determine whether this is the case or not. The beds upon the Aroostook are described in the report of Prof. Charles T. Jackson on the geology of Maine. Iron-ore of Maine.

It has been stated that, in the case of the Silurian beds so far described, these usually present some feature, either of composition, colour or contained fossils, by which their recognition is made easy. It is, however, now to be observed that, in addition to these, there are, over various parts of the Silurian area, other beds, of which the precise position is less readily determinable. The larger part of these are argillites which do not differ greatly from those already noticed, but which are usually less markedly calcareous, and which do not, so far as known, contain any organic remains. Good exposures of such slates may be seen at different points along the banks of the St. John River, as near Florenceville, between Bath and Upper Kent, on the hills about Perth, and at many other localities. They present some variety of colour and texture, including some greenish and purplish as well as grey beds, and both sandstones and slates. The absence, however, of any constant distinctive feature, makes their recognition and comparison at different points a matter of much difficulty. This difficulty is further enhanced by the very general and often highly complicated movements which these rocks, in common with the other Silurian strata, have undergone, and which makes the tracing out of individual beds well nigh impossible. It may even be that among the strata in question there are some which are older as well as others which are more recent than the Silurian system, as has been supposed to be the case in the northern part of the state of Maine, but of this we could here find no distinct evidence. The well known eminence of Mars Hill, along the eastern flank of which runs the International boundary line, and which attains an elevation above the sea level of 1,688 feet, has been thus regarded as in part of Devonian age, but the conglomerates of which it is composed, and which have been described as merely capping its summit, were found by Mr. McInnes, as far as they were seen by him in an ascent of its north-eastern side, to dip N. 75° W. at an angle of about 75°, and to be enclosed in slates not differing from those which elsewhere belong to the Silurian system. Argillites. Mars Hill.

Another set of beds, as to the precise relations of which there is also some doubt, consists, in part at least, of materials which are probably of igneous origin. These consist of diorites and dioritic sandstones, or of hard, felspathic beds, obscurely stratified, and appear to be very Trappean rocks

irregularly distributed over the Silurian area. One tract of this kind may be seen about two miles north of the post office in Glassville centre, where are grey-weathering, felspathic quartzites, which are more or less amygdaloidal. Another, forming some prominent ridges, is found on either side of the Little Shiktehawk, two miles east of Kent station, and includes heavy masses of dark-green, amygdaloidal diorite, a portion of which is stratified, and (at Lockhardt's mill) passes into a curious conglomerate containing dioritic fragments, from one to three feet in diameter, embedded in a matrix of a similar character. Still another occurs near the head-waters of one of the branches of the Munquart, five miles north of Johnville, and attains an elevation of nearly 1,000 feet. But the most marked area possessing this igneous aspect is that of Moose Mountain, in Upper Kent, and close by the boundary line between the counties of Carleton and Victoria. This eminence, which rises with singular abruptness from the comparatively low land about the head-waters of the Munquart, and attains an elevation of 1,030 feet, appears to be chiefly composed of a dark-grey, somewhat red-weathering felsite, porphyritic with small crystals of felspar. It is distinctly stratified, with southerly and south-easterly dips, at angles of 40° to 50°, and probably forms much of the ridge extending easterly from this point along the county line, but as the latter is thickly wooded, its exact limits could not be ascertained.

The rocks in these several belts are often not unlike those which are commonly met with in connection with the Cambro-Silurian system, and it may be that they are in part really of this age, forming bosses which, by denudation, have been left protruding through the more recent strata. As, however, there is no definite proof of this fact, and as the areas which they occupy are comparatively small, we have preferred to represent them merely as volcanic masses connected with the Silurian system.

Intrusive rocks.

It may now be added that over many different parts of the Silurian area, and among rocks which are unquestionably of this age, true eruptive rocks, both in the form of dykes and intercalated masses, are to be met with, and are sometimes very conspicuous. One instance of such occurrence may be seen along the east bank of the St. John, two miles above Hartland, and was referred to in the report of last year. Another was observed near the mill in the settlement of Esdraelon. But the most notable example is that furnished by the Aroostook River. In the remarkable and picturesque gorge through which this stream flows for three quarters of a mile above its falls, such dykes are quite numerous, varying from two or three up to fifty or more feet, and it is chiefly to the presence of a large mass of this kind, transverse to the stratification, that the falls themselves are due. Similar dykes, but

of less conspicuous character, occur also in the gorge below the Grand Falls of the St. John.

The review of the Silurian system now given may be closed by a slight further reference to the nature and extent of the physical movements by which its rock formations have been affected. Probably no features in connection with the latter are more noteworthy than the evidences everywhere afforded of profound movements and displacement. These are found in all portions of the system, but are especially remarkable in connection with the more highly calcareous banded slates, such as are found about Grand Falls and the Aroostook, where the foldings and twistings of the strata could scarcely be exceeded either for variety or complexity. Faults are also innumerable, and, as well exhibited in the last of the localities above named, are intimately connected with the igneous or trappean outflows, to which reference has been made. Yet notwithstanding these local corrugations, it is easy to see that the more comprehensive movements by which the region has been affected exhibit an approximate degree of parallelism, as is evidenced not only by the extension of certain belts, like those of the limestones and iron ores, across a large part of Carleton county, with a nearly uniform trend (about N. 10° E.), but by the general prevalence of dips at right angles to such trends. In most instances these dips are high, but occasionally, as can be seen along the valley of the Shiktehawk, they may be low or the beds may even be horizontal. In such cases, the existence of a well-marked and nearly vertical cleavage makes more than ordinary caution necessary in any observations upon the structure. Physical movements.

Remarks upon the economic minerals of the Silurian will be found in the sequel.

CAMBRO-SILURIAN.

In the report of last year it was stated that to the south of the Silurian rocks, and occupying very considerable portions of York and Carleton counties, is a series of rocks which is unquestionably older, and probably of Cambro-Silurian age. These were further described as consisting of two or more belts of metamorphosed strata which rest upon, or more correctly are penetrated by, great masses of intrusive granite, the alteration increasing in proportion as the latter is approached and being presumably connected with its presence. The same rocks extend into the region to which the present report relates, and present, for the most part, the same features. Position.

Of the several belts to which reference has been made, the more northerly enters the district under review along the valley of the St. John River not far above Woodstock, forming the western shore as far Northern belt.

north as Victoria corners, and the eastern nearly to the Little Pokiok River, two miles south of Hartland. Just east of this line, the same rocks also cover a large area, extending along the southern margin of the map as far eastward as a point nearly midway between the two branches of the Keswick River, a distance of twenty-two miles. This width is maintained, however, for a short distance only; for, a few miles to the north, the belt is not only overlaid by the great Carboniferous outlier of the Beccaquimic, already described, but is met, near Beccaguimic Lake, by great masses of intrusive granite, whereby it is divided into two much narrower belts. Of these the more northerly, beyond the Beccaguimic outlier, extends by the sources of the North Branch of the South-west Miramichi to and beyond the head of the Wapskehegan, one of the southern tributaries of the Tobique, while the other, crossing the granite or rather separating two granite areas, connects, towards the head of Nashwaak, with the second or southern belt of Cambro-Silurian rocks, extending thence to and beyond the South-west Miramichi. On the last-named stream the effects of irregular granite intrusion are again seen in the partial breaking up of the Cambro-Silurian rocks into separate belts, and in the great reduction in their breadth. The main belt, however, continues on, and leaves the limits of the map above the head-waters of the Dungarvon.

Distribution.

The Cambro-Silurian rocks of south-eastern Carleton county, as seen along the valley of the St. John River and again along the line of the New Brunswick railway, were fully described in the report of last year. Over all this tract the prevailing rocks are slates and sandstones which are usually of a grey colour, felspathic and often white-weathering; but some of the slates, as at Acker's Creek, are highly chloritic, with tints of green and red, while at other points they are associated with bedded diorites and felsites. None of the highly metamorphic strata (gneisses, mica-schists, &c.) which are so prominently developed in the south-western extension of the belt (as in Canterbury) have been met with here, but this may be largely due to the infrequency of exposures at the points where these might naturally be looked for. On the other hand there are, in the valley of the Beccaguimic, some beds apparently connected with the above, which are quite different from any elsewhere met with, and which are of special interest as affording the only direct testimony yet obtained as to their geological horizon. These are the black silicious slates and associated quartzites which have been referred to, on a previous page, as occurring in the bed of the last-named stream, a short distance above Shaw's mills. In his examination of these slates in 1880, Mr. G. F. Matthew observed the occurrence of flinty calcareous layers, and from the latter succeeded in obtaining a number of fossils,

Characters.

Silicious slates.

Fossils.

chiefly of small brachiopodous shells, but including also a few encrinal joints and an *Orthoceras*. During the past two seasons more ample collections of these fossils have been made by myself and Mr. McInnes, as well as by Mr. Thomas Reed of Fredericton, and in the material thus obtained, which has been submitted to Mr. Whiteaves, there have been found, not only numerous shells of a species of *Leptæna*, allied to *L. decipiens* of Billings, together with other brachiopoda, resembling *Lingulella*, *Strophomena* and *Discina*, but several trilobites referable to the genus *Harpes*. These last, like the shells, are unfortunately too fragmentary for specific determination, but the mere occurrence of this genus, of which three species, according to Mr. Billings, are found in the Trenton formation of Canada, is sufficient to show that the containing beds are at least Cambro-Silurian, if not possibly even older. The relation of these beds to the Silurian, and the fact that they have contributed material to the Silurian conglomerates, have been already noticed.

Southern belt. Of the more southerly belt of Cambro-Silurian strata, little need here be said. It enters the area to which the present report relates about the head-waters of Tay Creek, and thence extends, in a general north-easterly direction, across the Nashwaak and Taxes rivers, to and beyond the South-west Miramichi. **Characters.** Its lithological characters are much the same as those of the same belt in its south-western extension, as described in the report of last year, the prevailing rocks being slates and hard sandstones, of greyish, sometimes green or purple colour, between which and the granite there usually intervenes a greater or less mass of more highly altered strata, in the form of fine gneisses, mica- or staurolite-schists, and black, pyritous slates. Fine exposures of all these beds may be seen upon the Nashwaak, between Stanley and the mouth of the Napudogan, and they are again repeated, with similar relations, both upon the Taxes and the Miramichi, where they have been examined and reported on by Mr. Chas. Robb. As their characters, at all these points, bear the closest resemblance to the rocks of the Cambro-Silurian system as represented in other portions of York and Carleton, it is highly probable that they are in great part referable to this system. **Fossils on Rocky Brook.** It should not, however, be forgotten that it was in connection with this same belt of rocks that fossils were some years since observed by Mr. Edward Jack, and subsequently collected by Mr. Chas. Robb, which, according to Mr. Billings, appeared to indicate that the containing beds were of about the age of the Lower Helderberg formation, or of the Gaspé limestones. We have made several attempts to obtain additional facts as to the stratigraphical position of this fossil-bearing band, but with little or no success. The locality in which the first discovery was made was on a small branch of the Rocky brook, itself one of the

smaller tributaries of the Nashwaak, and in a region which is still densely covered with forest; but though rocks apparently identical with those containing the fossils were found both here and on the Taxes, neither the thin stratum in which they occur was again met with, nor could any further information be obtained as to their relations. In view of all these facts we must continue for the present to regard the stratum in question as part of an overlying formation, but involved with the Cambro-Silurian in the general system of folding by which the whole region has been affected.

A. B. Pre-Cambrian.

Mr. McInnis furnishes the following description of these rocks:—

The rocks which have been referred to this division on the accompanying map consist of a series of highly crystalline strata, and include gneisses, syenites, and felsites. They have been thought to form a continuation of the area of Pre-Cambrian rocks recognized by Mr. Ells as extending south-westerly in a gradually widening belt from the Nepisiguit, across the main North-west and Little South-west Miramichi Rivers, and described by him in the Report of Progress, 1879–80. The typical rocks of the formation as here represented are crystalline felsites, generally, though often obscurely, stratified, and hard, fine grained syenites, which not unfrequently merge almost insensibly into the felsite beds. Although including areas of gneissic rocks, they lack the distinctly schistose aspect which so markedly characterizes them, as described by Mr. Ells, in their extension to the North-east.

Typical rocks.

Igneous rocks.

Intruded masses of igneous rocks of very considerable extent without doubt occur within the limits here assigned to the Pre-Cambrian. No attempt has been made, however, to represent them on the map, as the inaccessible nature of the greater part of the region has prevented the accurate tracing of their outlines. The dissimilarity of the rocks of this formation to the intruded granites on the one hand and to the Cambro-Silurian strata on the other is very marked, and is well shown in the section afforded by the Clearwater stream, a tributary from the north of the main South-west Miramichi River, which cuts successively through the Pre-Cambrian, the intruded granites and the Cambro-Silurian rocks.

Clearwater brook.

Ascending this stream, ledges of red and grey intrusive granite of coarse texture with large crystals of felspar are first met with. Above, for a distance of about three and a-half miles, almost continuous exposures of hard, banded, felspathic quartzites, often chloritic, purple in colour, and holding iron pyrites, occupy the bed of the

stream, causing the occurrence along this part of its course of numerous falls and rapids.

These rocks are quite similar to the Cambro-Silurian strata seen in other parts of the district. They show the influence of the intrusion of the granite in their alteration in places into schists holding staurolite crystals and in their prevailing purple colour with conspicuous banding. Although much twisted and contorted, they maintain a general northerly dip at an angle of about 70° to 80°. Alteration.

After passing over a belt of coarse red granite with a width of about six miles, a continuation of that crossing Burnt Hill brook and main South-west Miramichi River, the first rocks of supposed Pre-Cambrian age are met with. They are reddish-grey gneisses, which shew an apparent dip N. 10° W. $<$ 30°, and are exposed along the stream for about half a mile. These are followed by ledges of hard, fine-grained, red syenite and felsite, obscurely stratified. This syenite, sometimes much coarser and with large crystals of red felspar, is seen along the stream and forms the high bordering hills for a distance of about six miles. A short distance below the crossing of the county line and also extending above the forks for about two miles, are ledges of hard, dark-grey, coarsely crystalline diabase, closely resembling that observed about the lake at the head of South Branch Beccaguimic. Between the county line and the forks are ledges of hard, pinkish, black specked, crystalline felsite dipping S 50° E $<$ 70°. Clearwater brook.

The southern border of the Pre-Cambrian area is defined on Burnt Hill brook and on the North Branch of South-west Miramichi by the upper edge of the intruded granite. This granite belt, which has on the Clearwater a breadth of about six miles, on the Burnt Hill brook extends from about a mile above the mouth to the confluence of Green brook and South Branch, where it cuts compact red quartz porphyry dipping N. 25° E. $<$ 70°; and on the Miramichi from just below McDonald's brook to about a mile and a quarter above Bedel Brook on the North Branch. Granite belt.

In an ascent of this branch, the first exposures seen were about nine miles above the forks, and were of reddish-grey granite with black mica. For a short distance above and below Bedel brook, eleven and a-half miles up, ledges of granite were also seen in the stream. About thirteen and a-half miles up a ledge of crystalline, grey felsite, merging into a red syenite, occurs. About a mile below the falls (seventeen miles above the forks) bright-red felsite occurs, followed by grey and black-specked felsite, and hard, greenish-grey syenitic trap. The falls themselves occur over fine, hard, grey and slightly amygdaloidal, felsitic rocks, with specks of iron pyrites. About a quarter of a mile above the falls are ledges of hard, grey, felspathic sandstone, looking very like Cambro- North Branch.

Silurian, and dipping N. 55°, W. < 60°. Then follow greenish traps again, concretionary in structure in places, and having large nodules, like cannon balls, weathering out of the face of the ledge. These are seen to a point about 800 yards above the falls, where the stratified felspathic sandstone again appears, dipping N. 55° W. < 79°, cut by greenish-grey trap. These traps and very hard greenish diorites continue to a point about three-quarters of a mile above the falls. Above this no exposures were seen. A point eighteen miles, or thereabouts, above the forks was reached.

The felspathic sandstones above described have been considered as marking the eastern limit of the Cambro-Silurian belt. Not only do they resemble the rocks of this formation lithologically, but their strike quite accords with the general trend of the band. The other rocks, although they undoubtedly include many of intrusive origin, so closely resemble the succession presented by the Pre-Cambrian rocks in other parts of the district, that they have been thought to probably form a part of this formation, and have been so represented on the accompanying map. Felsites, which may be of a similar age, were described last year as forming a long ridge east of Mapleton, near the southern limit of the map, and have also been observed about Lawrence Peak, and on the branches of the Beccaguimic.

Felsites.

In addition to the area above described, Mr. Ells also refers to this division a band of gneiss which shows in low-lying ledges for about two miles along the South-west Miramichi River four miles below the forks.* Coarse granitoid gneiss without apparent bedding, which probably belongs to the same band, forms the high ridge, known as Nashwaak mountain, about three-quarters of a mile to the South-west of the forks above mentioned. As here seen it is in places nearly white from the deficiency or absence of the black mica which gives to it its general grey colour, and in places resembles an agglomerate, quartz, felspar and mica occurring in small rounded pieces like pebbles scattered through it, and encloses large blocks of a hard fine-grained, dark-grey gneiss, quite distinct from the including matrix. As it has been found impossible to separate the gneisses which may be of Pre-Cambrian age from rocks which may be intrusive, the former have been included on the map in the general granitic area.

Nashwaak mountain.

Intrusive Granites.

The character of the granites of York and Carleton counties, with the facts from which their intrusive origin is inferred, having been fully detailed in the report of last year, it only remains to define more par-

* Report of Progress 1879-80, page 32 D.

ticularly the areas which they occupy within the region embraced by the present report.

Of these granitic areas one enters the limits of the map near the middle of its southern margin, being a continuation of a long belt of such rocks extending north-easterly from the St. John River. It was also at one time supposed to be continuous with one or other of the several belts of such rocks found on the South-west Miramichi River, between Rocky brook and the Clearwater. In an examination, however, of the Taxes River and of the Napudogan and other brooks flowing into the Nashwaak from the north, Mr. McInnes found that the Cambro-Silurian sandstones and slates, striking N. to N. 20° E. and dipping at a high angle, extended in a succession of anticlinal and synclinal folds over the whole of this region. It therefore seems probable that the first described area, already narrowed on the Nashwaak, terminates just east of the latter, beyond the Napudogan, while the belts referred to on the South-west Miramichi are also limited to the vicinity of the latter. The main band of granite however, which begins in the Beccaguimic region, widens rapidly and on the Miramichi attains a breadth of not less than fifteen miles, its eastern limit being two and a-half miles above Slate Island brook, while the western is not far removed from the North Branch of the first-named stream. Areas described.

Economic Minerals.

The following economic minerals are, to a greater or less extent, to be found within the area to which this report relates:—

Iron Ores.—These include the hæmatites and limonites of Carleton county, the distribution and relations of which are described in a previous part of this report. Having been at one time the basis of a somewhat extensive and prosperous industry they have received a considerable amount of attention and have been fully described both in the reports of the geological survey and elsewhere. It is now some years since the works were in operation, and with the increased cost of production it is doubtful whether they will be again renewed.

Limestones.—It has been already stated, on a previous page, that the calcareous strata of the Silurian system are in places accompanied by beds of limestone sufficiently pure to be available as sources of lime, and details of their distribution and relations have been given. Quarries have been opened at a number of points and kilns erected, but there are only two at which operations have been carried on upon anything like an extended scale. One of these is that known as Turner's kiln, in

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The felspathic sandstones above described have been considered as marking the eastern limit of the Cambro-Silurian belt. Not only do they resemble the rocks of this formation lithologically, but their strike quite accords with the general trend of the band. The other rocks, although they undoubtedly include many of intrusive origin, so closely resemble the succession presented by the Pre-Cambrian rocks in other parts of the district, that they have been thought to probably form a part of this formation, and have been so represented on the accompanying map. Felsites, which may be of a similar age, were described last year as forming a long ridge east of Mapleton, near the southern limit of the map, and have also been observed about Lawrence Peak, and on the branches of the Beccaguimic.

Felsites.

In addition to the area above described, Mr. Ells also refers to this division a band of gneiss which shows in low-lying ledges for about two miles along the South-west Miramichi River four miles below the forks.* Coarse granitoid gneiss without apparent bedding, which probably belongs to the same band, forms the high ridge, known as Nashwaak mountain, about three-quarters of a mile to the South-west of the forks above mentioned. As here seen it is in places nearly white from the deficiency or absence of the black mica which gives to it its general grey colour, and in places resembles an agglomerate, quartz, felspar and mica occurring in small rounded pieces like pebbles scattered through it, and encloses large blocks of a hard fine-grained, dark-grey gneiss, quite distinct from the including matrix. As it has been found impossible to separate the gneisses which may be of Pre-Cambrian age from rocks which may be intrusive, the former have been included on the map in the general granitic area.

Nashwaak mountain.

Intrusive Granites.

The character of the granites of York and Carleton counties, with the facts from which their intrusive origin is inferred, having been fully detailed in the report of last year, it only remains to define more par-

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* Report of Progress 1879-80, page 32 D.

ticularly the areas which they occupy within the region embraced by the present report.

Of these granitic areas one enters the limits of the map near the middle of its southern margin, being a continuation of a long belt of such rocks extending north-easterly from the St. John River. It was also at one time supposed to be continuous with one or other of the several belts of such rocks found on the South-west Miramichi River, between Rocky brook and the Clearwater. In an examination, however, of the Taxes River and of the Napudogan and other brooks flowing into the Nashwaak from the north, Mr. McInnes found that the Cambro-Silurian sandstones and slates, striking N. to N. 20° E. and dipping at a high angle, extended in a succession of anticlinal and synclinal folds over the whole of this region. It therefore seems probable that the first described area, already narrowed on the Nashwaak, terminates just east of the latter, beyond the Napudogan, while the belts referred to on the South-west Miramichi are also limited to the vicinity of the latter. The main band of granite however, which begins in the Beccaguimic region, widens rapidly and on the Miramichi attains a breadth of not less than fifteen miles, its eastern limit being two and a-half miles above Slate Island brook, while the western is not far removed from the North Branch of the first-named stream. Areas described.

Economic Minerals.

The following economic minerals are, to a greater or less extent, to be found within the area to which this report relates:—

Iron Ores.—These include the hæmatites and limonites of Carleton county, the distribution and relations of which are described in a previous part of this report. Having been at one time the basis of a somewhat extensive and prosperous industry they have received a considerable amount of attention and have been fully described both in the reports of the geological survey and elsewhere. It is now some years since the works were in operation, and with the increased cost of production it is doubtful whether they will be again renewed.

Limestones.—It has been already stated, on a previous page, that the calcareous strata of the Silurian system are in places accompanied by beds of limestone sufficiently pure to be available as sources of lime, and details of their distribution and relations have been given. Quarries have been opened at a number of points and kilns erected, but there are only two at which operations have been carried on upon anything like an extended scale. One of these is that known as Turner's kiln, in

the valley of the Beccaguimic, and the other as Henderson's in Windsor settlement, a few miles to the north of the former. The annual production at Turner's is said to be about 500 casks (2,000 bushels) and to be valued at from $1.00 to $1.40 per cask. It is used chiefly for local consumption but is frequently sent as far down the river as Woodstock. The Hendersons first commenced burning lime in 1880, since which time their annual production has averaged about 1,000 bushels.

Gypsum.—The deposits of this mineral accompanying the Lower Carboniferous strata of the Tobique valley, in Victoria county, are extensive and valuable. Their total amount, owing to the horizontal position of the beds and the want of exposures, is not accurately known, but from the length and thickness of the outcrops seen on the main Tobique and its tributary the Wapskehegan, it is certain that the amount is large. On the first named stream the beds form nearly vertical bluffs about 130 feet high, and consist of numerous alternating bands of pale green, and reddish colours, and granular texture, among which are smaller seams of white fibrous gypsum and amorphous alabaster.

This gypsum is employed solely for agricultural purposes and considerable quantities are used in this way not only in Victoria county, but in all those parts of the St. John River valley to which access is given by the New Brunswick railway. Though admirably adapted for this use, it is greatly inferior in purity to that of Hillsboro, and is hardly suited for calcination.

Lead.—Small quantities of galena have been observed in the calcareous slates in the lower portions of the Tobique River, as well as elsewhere over the Silurian area, but in no instance at present known are they of a character to warrant a belief in the existence of workable veins.

Building Stones.—The Carboniferous outlier about the South Branch of the Beccaguimic River, according to Mr. Matthew, is capable of affording good freestones, of even grain, easy to work, and which dress well under the chisel. The outcrops are about seven miles from Woodstock junction on the New Brunswick railway, to which a good road could be had through a comparatively level country.

The slates of Carleton county are usually too much contorted and too calcareous to be available for roofing purposes. There are however among them beds to which these remarks do not apply, and should a greater demand arise, a little search would undoubtedly reveal localities from which suitable rock could be readily and profitably removed.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA
ALFRED R. C. SELWYN, LL.D., F.R.S., F.G.S., DIRECTOR.

PRELIMINARY REPORT

ON THE

SURFACE GEOLOGY

OF

NEW BRUNSWICK

BY

R. CHALMERS.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.
1885.

ALFRED R. C. SELWYN, ESQ., LL.D., F.R.S., ETC.,

Director of the Geological and Natural History Survey of Canada.

SIR,—I beg to present herewith a report on the Surface Geology of the Province of New Brunswick, chiefly the result of observations made during the summer of 1884. Illustrative maps showing the character and distribution of the surface deposits, are in course of preparation. These are based on the quarter-sheet topographical maps of the Survey, the surface geology being laid down upon them according to a system of coloring and notation. They will be issued as soon as the necessary data to complete them have been obtained.

My thanks are due to the New Brunswick Railway Company for a free pass over their lines; to Prof. Harrison, of the University of New Brunswick, for a list of barometric readings; to T. G. Loggie, of the Crown Lands Office, Fredericton, G. F. Matthew, M.A., St. John, and Rev. C. R. Matthew, Kingsville, Ont., for information relating to the depths of Grand and Washadamoak Lakes and the Kennebeckasis River, etc.

I have the honor to be,

Sir,

Your obedient servant,

R. CHALMERS.

OTTAWA, May, 1885.

PRELIMINARY REPORT

ON THE

SURFACE GEOLOGY OF NEW BRUNSWICK.

The explorations of the past season (1884) relating to the surface geology of New Brunswick extended to all parts of the province, and a number of important facts were discovered. The area included in the eastern and northern counties was examined more in detail than other portions, partly because its surface deposits had not hitherto been studied, except in a preliminary way, and partly owing to the fact that data of considerable scientific value were found there in the course of the season's investigations, which, it was considered, might aid in solving the perplexing problem of the glaciation of Eastern Canada. **Area explored.**

The observations of geologists on the glaciation of New Brunswick, previous to 1884, having been largely confined to the southern and western counties where the striæ met with have a general southerly or southeasterly bearing, it was therefore inferred that this direction indicated the general ice-movement over the whole province. The investigations of the season of 1884*, however, show that north and east of the water-shed dividing the waters of the St. John River from those flowing into the Baie des Chaleurs and Gulf of St. Lawrence, there was an easterly and northerly ice-movement during the Ice Age, accompanied by a heavy transportation of drift from the interior towards the coast; that is to say, the water-shed referred to seems also to have shed the ice of the glacial epoch northward and southward, the glacier or glaciers on the southern side moving in the direction of the Bay of Fundy, while those on the northeastern side moved down the opposite slope into the depression now occupied by the Gulf of St. Lawrence. In addition to these ice-movements, however, striæ have been found on the last mentioned slope, indicating a separate and independent ice-flow, either directly northward or southward, which are referred to a later or second period of glaciation. All the facts relating to these will be found tabulated and details given in a subsequent part of this report. **Observations previous to 1884.** **Glaciation of New Brunswick.**

* The writer first treated of the glacial phenomena of the northern part of the province in a paper published in the *Canadian Naturalist* in 1881, Vol. X., No. 1.

Quarternary oscillations of level.

The marine deposits along the coast were also studied and facts obtained which serve to show their horizontal and vertical distribution as well as the oscillations of level which the region underwent, approximately, during the Quaternary epoch. The amount of these oscillations is estimated on the evidence of marine fossils, old shore lines, and drift-filled estuaries.

Barometric measurements.

A complete hypsometrical section of the province was made along the Tobique and Nepisiguit Rivers, in which the elevations of a number of the principal mountains and lakes of the interior above sea-level were measured barometrically, and the height of the general surface of the country ascertained with, it is hoped, a tolerable approach to accuracy. Many facts relating to its agricultural character, fauna, flora, etc., were also observed. From the upper waters of the Nepisiguit a descent of the Upsalquitch River was made by way of Portage Brook and Upsalquitch Lake, and the general surface features and agricultural capabilities of that section were noted. A large tract of excellent farming land exists on the upper waters of the Restigouche, as referred to by Mr. R. W. Ells, Report D., (Report of Progress, 1879-80) which will be available for settlement as soon as some means of communication are provided. This tract is sometimes called the "Fertile Belt," but above the mouth of the Patapedia, owing to its remoteness, want of roads, etc., it is yet entirely unsettled.

Agricultural character of northern New Brunswick.

Towards the close of the season (1884) the Madawaska valley was visited and the character of the country along the upper St. John, in reference to its agricultural value, and otherwise, specially observed, and data regarding its surface geology collected. This section of the province, which includes Madawaska county and a part of Restigouche, it may be remarked, comprises some fine intervales and uplands.

Rock-bound lake basins.

The discovery of true rock basins holding small lakes in the Laurentian and Huronian rocks lying to the northeast of the city of St. John, was not one of the least interesting results of the season's operations. Details regarding these, as well as many other matters not referred to here, will be given in the following pages.

Fossils.

Collections of fossils were obtained from the marine clay of the Baie des Chaleurs basin, which are enumerated under the head of "Leda Clay and Saxicava Sand." Among them is a claw of the lobster (*Homarus Americanus*) discovered for the first time in the Leda clay of Restigouche. Specimens of brick-clay for the museum were obtained from brick-yards in operation at St. John, Moncton and Fredericton, and considerable collections of the flora of the province were also gathored, partly by Mr. G. U. Hay, who accompanied me as a volunteer on a trip up the Tobique River, and partly by the writer.

Flora.

In preparing this report it is considered necessary to revise, to some-

extent, the nomenclature in use pertaining to surface geology, and the new classification and notation are accordingly adopted* which have reference to the sub-divisions of the subject as outlined in the Geology of Canada, 1863, page 887. This classification will be employed in this report and in the preparation of maps illustrating the character, distribution, etc., of the surface deposits, and it is hoped will be sufficiently practical and systematic for all investigations in this branch of geology for some time to come. Details regarding the coloring and notation of these maps will be found elsewhere. The system now adopted will, no doubt, require modifications from time to time as our knowledge advances, and therefore is, to a certain extent, merely provisional, especially that of Division M2 into "fresh-water" and "marine beds," the term "interior, fresh-water" deposits being employed for the present to designate those beds supposed to be of the same age as the Leda clay and Saxicava sand, but which occur in the interior apparently where the sea has not reached during the Quaternary epoch. The evidence as to their fresh-water origin, especially in New Brunswick, is still to a large extent negative, no fossils having been found in them. Revision of nomenclature of surface geology.

The names "Saxicava sand" and "Leda clay," first proposed for certain beds in the St. Lawrence valley by Principal (now Sir William) Dawson, will be restricted exclusively to the known marine fossiliferous deposits consisting of sand, gravel and clay, which are intermediate between the till or boulder-clay (division M1) and the recent deposits (division M3).

CLASSIFICATION OF SURFACE DEPOSITS.

M 3.

Alluviums, or Recent Deposits.

(*a*)	(*b*)
Fresh-water beds; (fluviatile and lacustrine); marshes, peat bogs, or caribou plains, and river flats (intervales).	Marine beds; salt marshes, sand dunes, estuarine flats, etc.

M 2.

Stratified Sands, Gravels and Clays.

(*a*)	(*b*)
Interior, fresh-water sands, gravels and clays (fluviatile and lacustrine, etc.)	Saxicava sand and Leda Clay (marine fossiliferous beds).

M 1.

Till, or Boulder Clay.

* See Report of Progress, 1880-81-82.

The fresh-water and marine beds, (*a*) and (*b*) of division M 2, are supposed to be largely of contemporaneous formation, and the same remark applies to (*a*) and (*b*) of division M 3.

Moraines and kames are not classed with any particular division at present, as they may belong, partly at least, to either M 1 or M 2. Their occurrence is merely local and phenomenal, and moreover they do not occupy areas of any great extent either on the surface or, so far as observed, beneath it.

The term kame is somewhat enlarged in signification from that used in my last report (Report of Progress, 1882-83-84) and is here employed as including not only kames of the interior, such as those occurring on the higher levels and in river valleys, but also those wide, flat ridges of sand and gravel met with along the coasts of the Bay of Fundy and Baie des Chaleurs. The latter have been regarded by Mr. G. F. Matthew as of marine origin (Report of Progress, 1877-78 E E), and seem to have been at least remodelled by marine currents.

Topographical Features of New Brunswick.

Chief topographical features.

The topographical and orographical features of New Brunswick are largely dependent upon the geological structure and the character of its rock-formations. The more salient points of these may be thus outlined and succinctly stated in general terms: —

Main water-shed.

1. A main axis or central water-shed traversing the province from the extreme northwest corner southeastwardly to the isthmus of Chignecto, or to the Nova Scotia boundary. This low axial ridge, while it has a general northwest and southeast direction, nevertheless sweeps round to the south with an extensive curve in the central part, and in Carleton county, along the upper waters of the South-West Miramichi, approaches near the St. John River, thence, however, extending almost due eastwardly past the northern end of Grand Lake or Salmon River, Queen's county, its course from there being about southeasterly to the isthmus as already mentioned. 2. A northeasterly slope from this water-shed to the coast, drained by the numerous rivers of this part of the hydrographical basin of the St. Lawrence, chief among which are the Restigouche, Nepisiguit, Miramichi and Richibucto; and 3. A southwesterly slope drained by the St. John and its tributaries and also by the St. Croix, Digdeguash, Magaguadavic, New and other rivers into the Bay of Fundy. Traversing this latter slope is a second or subordinate water-shed, referred to in report GG (Report of Progress, 1882-83-84) approximately parallel to the main one described, and constituting a divide between the St. John valley and the Bay of Fundy. It extends from King's county, in the vicinity of Long Reach on

Subordinate water-shed.

the St. John River, southwestwardly to the International boundary and beyond it. Each of these has numerous minor axes or water-sheds, sometimes branching off from the principal one, but often apparently without any connection with it, and irregular in direction; and thus while the chief topographical features of the province are comparatively simple, they nevertheless present in detail many complexities, mountain and hill ranges as well as enclosed valleys running to all points of the compass, and contributing to form, in many places, a highly diversified surface.

Height of main water-shed.

The general elevation of the principal water-shed referred to, in which are to be found the highest mountain ranges and peaks in the province, is, in Madawaska and Restigouche counties, 800 to 1000 feet above sea-level; at Nictor and Nepisiguit Lakes, 1,000 to 1,200 feet; from these lakes to the upper waters of the South-West Miramichi, 1,200 to 1,300 feet; on the divide between the Taxis and Nashwaak rivers, 900 to 1000 feet, where the road from Boiestown to Fredericton crosses it, 650 feet; across the central part of the Carboniferous area between the Nashwaak and the head of the Cocagne River, 150 to 300 feet. Between Moncton and Shediac it is 100 to 150 feet; on the ridge between the Memramcook valley and Cape Bald, 125 to 200 feet, and between Cumberland Basin and Baie Verte, 10 to 20 feet. Along that portion of the water-shed lying between the head of the Tobique River and the western limit of the Middle Carbonaceous area, mountain and hill ranges with scattered peaks rise to heights of 2,000 to 2,500 feet above the sea, giving the region, when viewed from some prominent summit, a bold and rugged outline, and leading the observer to imagine the general level to be much higher than it really is. The grandest and most picturesque scenery of the province occurs in this part, that is, between the Silurian area on the north and the Carboniferous on the south, where the Tobique, Nepisiguit and Miramichi rivers take their rise. (See report of Mr. Ells in Report of Progress, 1879-80.)

Height of subordinate water-shed.

The height of the second or subordinate water-shed between the St. John River and the Bay of Fundy does not, in general, exceed 700 to 800 feet above sea-level. Several peaks, however, rise to an elevation of 1000 feet; but this water-shed is intersected by transverse, or north-and-south valleys, the bottoms of which are not more than from 300 to 500 feet above the sea. The general features of this region are described in my report on the surface geology of western New Brunswick already cited; but it may be stated, in addition, that the eastern extension of this water-shed is characterized by short, hilly ranges and isolated peaks, which include the Nerepis mountains, as well as Douglas, Bull Moose and Broke Neck mountains, and others east of the St. John River. Between this divide and the coast of the Bay of Fundy are numerous

hills and ridges described in Bailey and Matthews' report (Report of Progress, 1870-71), through which the rivers have cut deep channelways; so that, although as high, and in some instances higher, than the water-parting referred to, they nevertheless offer no obstacle to the drainage from it into the bay.

General Surface Features of the Slopes.

Surface features of slopes.

The more prominent surface features of that part of New Brunswick lying on the northeastern slope of the chief water-shed mentioned, may be briefly stated as follows:—

Northeastern slope.

1. An elevated and rugged district in the interior, about the upper waters of the Miramichi, Nepisiguit and Upsalquitch Rivers, which is from 1000 to 1500 feet in height above sea level, but includes numerous mountains from 2000 to 2500 feet in altitude; (2) an undulating plateau in the north, occupied chiefly by Silurian and Cambro-Silurian rocks, with a height varying from 800 to 1200 feet; and (3) a low, gently undulating, or nearly level area in the eastern part underlaid by Carboniferous sandstones, etc., which has a gradual slope from a height of 400 to 600 feet along the western margin down to the shores of the Gulf. The whole eastern coast region of the province, indeed, from Baie Verte to the mouth of the Restigouche, is low, forming a sort of inclined plane, descending beneath the sea at a low angle.

Southwestern slope.

The southwestern slope exhibits much greater diversity of features, the St. John valley, which extends throughout the whole province from northwest to southeast, being, perhaps, the most noticeable. From the summit of the principal water-shed described, there is a gradual slope to this valley, as also from the shorter divide on the southwest. The highest land is in the Tobique region, and at the head of the Shiktehawk and South-West Miramichi rivers. Mountains and broken ranges traverse this elevated tract in all directions and cross the St. John valley in the vicinity of Mars Hill (1688 feet high), extending into the State of Maine. To the north and northwest, in Victoria and Madawaska counties, the surface is rolling beyond the river valleys, and elevated 800 to 1000 feet on a general level above the sea, with occasional summits, such as the Belleville and Green Mountains, etc., rising considerably higher. To the south of Shiktehawk River the country is also rolling and the general level 600 to 800 feet above the sea. This latter tract, which comprises Carleton county and part of York, has already been described in report GG (Report of Progress 1882-83-84). The area occupied by Carboniferous rocks on the southwestern slope is here, as elsewhere, comparatively low and flat, varying in height from 200 to 600 feet above sea level, but having

a slight descent eastward to the limit of the Cambro-Silurian and other rocks overlapped by it on the south. The country underlaid by these older rocks, again becomes hilly and broken, and is traversed by ridges rising 500 to 1000 feet above the Bay of Fundy, their longitudinal direction being usually parallel to the coast line. These ridges occupy a considerable area in Charlotte, King's, Queen's, St. John and Albert counties, often with intervening valleys parallel thereto or to the coast, as well as those transverse valleys referred to, through which the rivers flow, the bottoms of which, as already stated, are at all levels from that of high tides in the Bay up to 400 and 500 feet above it. The general topography of this coast area has, however, been fully described in former reports (Report of Progress, 1870-71, also Report for 1877-78), and it is, therefore, unnecessary to dwell upon it here. Suffice it to say, that the region referred to, from Shepody Mountain, in Albert county, to the St. Croix River, is extremely rugged and barren, and from the nature of the underlying rocks, much of the soil is poor and stony.

Character of region bordering Bay of Fundy.

Heights of some of the Principal Mountains in or near the Main Water-shed.

From the foregoing outline of the topography of the province, it will be seen that the highest land is that occupying the central part of the northern half, and, as already stated, lies in the area drained by the southeastern branches of the Tobique, the South-West and North-West Miramichi, and the Nepisiguit and Upsalquitch rivers. Bald (Sagamook) Mountain, at Nictor Lake, is 2537 feet above sea level; Mount Teneriffe, the highest peak immedialely south of the Nepisiguit Lakes, is about the same elevation. Numerous other mountains are to be seen in the vicinity of these lakes and along the upper reaches of the Nepisiguit River, their bare red summits often rising 2000 feet high. One of these, about three miles above Indian Falls, or fifty miles from the mouth of the Nepisiguit (also called Bald Mountain), was found to be 1922 feet above the level of the Baie des Chaleurs. From its summit, the Miramichi River and valley, and the Gulf of St. Lawrence, were distinctly visible. On the portage from Nepisiguit River to Upsalquitch Lake, several remarkable mountains were noticed, among them a symmetrical, dome-shaped one, immediately southwest of the lake, stands up conspicuously in the valley, affording a splendid outlook from its summit. Its elevation, according to Hind, is 2186 feet. Upsalquitch Lake is surrounded with peaks, no fewer than ten being visible from its surface. Along the Tobique River, several ranges and isolated mountains also of great beauty were observed. Bald Head, on Riley

Heights of mountains in the interior.

Brook, is one of the most striking, its elevation, according to Hind, being 2240 feet above the sea. The Blue Mountains form the most prominent feature of the Tobique valley, their highest peak being 1724 feet above sea level, and 1250 feet above the river at their base. The loftiest mountains in this elevated tract, however, occur, according to Mr. R. W. Ells and other explorers, on the Big South Branch of the Nepisiguit, that is, between Nictor and Nepisiguit Lakes on the north, and the Right Hand Branch of the Tobique on the south, where some peaks attain a height of 2600 to 2700 feet above sea level.

Blue Mountains, Tobique valley.

Around the central highlands described, the surface of the country is rolling and broken, sloping away nevertheless almost imperceptibly in all directions from it, the descent, however, being less to the northwest than to any other point. From the summit of Sagamook Mountain, Nictor Lake, one can look over the great Silurian plain to the north and northwest, and see beyond it the elevated range of the Notre Dame and Shickshock Mountains looming up; but the slope from this region is greater towards the Gulf of St. Lawrence than in any other direction, as evidenced by the rapid descent of the rivers. The Nepisiguit River descends 1,000 feet in ninety miles, and the Upsalquitch 800 feet in about forty-five miles. What the descent of the Miramichi waters is was not ascertained, but it must likewise be considerable, especially on the Little South-West. The Tobique descends about 635 feet in its entire length of ninety-five miles.

View from Sagamook Mountain.

Descent of rivers.

RIVER SYSTEMS AND LAKE BASINS.

The rivers of New Brunswick are numerous, and some of them large. No country in America is better watered. The St. John is the great artery, draining about 10,500 square miles in the province alone, the total area of New Brunswick being computed at 27,490 square miles.* Next in importance and drainage area is the Miramichi, with its numerous branches ramifying throughout Northumberland county and a part of Sunbury, York, Carleton and Victoria, and draining no less than 5,500 square miles of territory. The Restigouche is the third largest, and while forming the boundary between the provinces of New Brunswick and Quebec for a part of its course, is, above the confluence of the Patapedia, entirely within the first-named province. Its extreme length is about 150 miles, and its drainage area in New Brunswick about 2,200 square miles. Next in size is the Nepisiguit, which is about ninety miles long, and traverses a rugged country, but has a much smaller drainage area than the rivers mentioned. It is, however, the swiftest and most difficult for the *voyageur*.

Area drained by the St. John.

Miramichi River.

Restigouche River.

Nepisiguit River.

* Twenty-third Annual Report of the Crown Land Department of New Brunswick, 1884.

Several of the tributaries of the St. John within the province are really rivers of considerable size, such as Oromocto, Nashwaak, Eel, Tobique, Green, Madawaska, etc. The Tobique is one of the largest, rising in the highland region at Nictau Lake and draining an area of about 1,500 square miles. The St. Croix, Digdeguash and Magaguadavic flowing into the Bay of Fundy, are also important streams and along with New River drain the chief portion of the slope on the secondary or southwestern water-shed.

Tributaries of the St. John.

In reference to the drainage of the province, however, it appears to have been, in pre-glacial times, somewhat different from that which at present obtains. While all rivers and streams of any size examined, seem, from the depth of their valleys,—often cut into the hardest rocks,—and the presence of till in such valleys underlying the fluviatile deposits, to have had a preglacial existence, nevertheless, the changes produced on the surface of the country during the Ice Age have caused them, in certain places, to leave their old channels and excavate new ones, often through solid rock. Moreover, drainage areas around the heads of rivers, and also lakes, if such existed in pre-glacial ages, may have had larger or smaller catchment basins, and these too may have been partially drained in other directions than by existing water-courses. Further, the greater elevation of the region at that time relatively to the sea level, as evidenced by a number of facts, some of which will now be adduced, enabled the rivers to cut their channels, and the valleys through which they flow, more deeply, by giving them greater erosive power, especially in the lower part of their courses. The facts observed as indicating a greater pre-glacial elevation in the Bay of Fundy region may be summarized as follows:—the estuarine character of the St. John River as far up as Fredericton; the tidal lake-like expansions of Kennebeckasis River and Belleisle Bay along with Washadamoak and Grand Lakes, these bodies of water being the result of the ponding back of the St. John owing to the obstruction at its mouth and the subsidence of the region in later Quaternary times. In pre-glacial ages, Salmon River, instead of emptying into Grand Lake, must have flowed along the bottom of the depression containing it into the St. John, and so with Canaan and Kennebeckasis Rivers. These sheets of water are, therefore, arms of the lake expansions of the Lower St. John, and occupy valleys which were eroded partly by the streams flowing into or through them, and partly by sub-aerial agencies in the period referred to. The maximum depth of Grand Lake, so far as can be ascertained, is about 30 feet; of Washadamoak, about 100 feet; of the St. John River, in Long Reach, 106 feet, but immediately above Indiantown, 198 feet (from the Admiralty charts); of Kennebeckasis Bay, 78 feet, and of Kennebeckasis River, in the deepest part, about 200 feet.

Pre-glacial drainage and river valleys.

Facts indicating a greater pre-glacial elevation of the region.

Grand and Washadamook lakes, etc., how originating.

Estuaries of other rivers.

All the other larger rivers of the province flowing directly into the sea also have estuaries of considerable length, except the Nepisiguit, the probable cause of which will be explained further on. The tide flows up the North-West Miramichi to Redbank, about thirty-five miles from its mouth, and up the South-West about the same distance. Tide head on the Restigouche is twenty-four miles from its mouth; on Richibucto River twenty-two miles; on the Nepisiguit the tide flows up only three miles above Bathurst Harbor. In the Bay of Fundy district the river valleys are penetrated by the sea, to greater or less distances, similarly to that of the St. John,—Magaguadavic as far up as the "falls" at St. George, six miles from its mouth, and the St. Croix to St. Stephen, sixteen to seventeen miles.

Sections of borings made across Restigouche and Miramichi valleys.

The sections of borings made across the Restigouche and Miramichi river valleys during the construction of the Intercolonial railway, and represented in the accompanying diagrams, will also illustrate the question under consideration as to the height of the region in the Tertiary or pre-glacial period.

At the mouth of the Metapedia River, where the Intercolonial railway bridge spans the Restigouche, borings were made which are represented by Fig. III. The borings made for foundations to the North-West and South-West Miramichi bridges are represented by Figs. I. and II.

Depth of river valleys in pre-glacial times.

These sections show that at some period anterior to the deposition of these clay beds, the Restigouche flowed in this part of its valley 70 feet below its present level, and the Miramichi 112 feet below the present sea level.

Conclusions as to greater pre-glacial elevation of region.

Correlating all the facts bearing upon this question in the north and south of the province, they indicate a pre-glacial elevation of the region of 100 feet or more above that of the present day relative to sea level. The depth of the Kennebeckasis and certain parts of the St. John valley which are in excess of this may be taken as indicating a still greater elevation than that given above; but on the other hand it is probable these depressions have been formed wholly by secular rock decay and subsequent scooping out by glaciers instead of by river action.

Probable difference in volume of rivers, notably the Nepisiguit.

But with regard to the drainage of the province it may be stated further, that some of the rivers seem, in pre-glacial times, to have had a larger or smaller volume of water, as the case may be, from one cause or another,—this supposition alone explaining some anomalous facts. Taking the Nepisiguit River as an example, we find that from the Narrows to its mouth, about twenty-five miles, its valley appears to be largely of Post-Tertiary origin. Either the lower part of the river took another course in pre-glacial ages, or the whole river itself has been of smaller volume. The drift holding in the lakes at its head

being of glacial origin, it follows that prior to its deposition and arrangement around their borders a portion of the waters now drained off by the Nepisiguit may have escaped by the Tobique,—Nictor Lake, which is only two and a half miles from the upper Nepisiguit Lake, being 165 feet lower than the latter and apparently connected with it across the water-shed by valleys now drift-filled. In this case, the pre-glacial Nepisiguit would not be as large as its successor, precipitation being equal. At all events, the limited drainage area of this river in comparison to its length, the absence of an old drift-filled channel at or near Grand Falls, and the rock-bound channel still being eroded more deeply at the Narrows, Grand Falls, Middle Landing, Pabineau Falls, etc., together with the fact of its flowing over a rock-bed till within three miles of its mouth indicate, when viewed in relation to other river valleys, the post-glacial excavation of its valley especially in the lower part of its course. It should not be forgotten, however, that for the most part, this river flows through a district occupied by Pre-Cambrian and Cambro-Silurian rocks, which wear down much more slowly than those of other parts of the country.

Examples might be cited, were it necessary, to show that when lakes or drainage basins existing on water-sheds are drained by outlets on opposite sides, as is sometimes the case, if one of these becomes closed by any means, the volume of the other must naturally be increased and excavate a larger channel.

The changes in the drainage referred to, have, in some places, resulted in producing water-falls and gorges from the damming up of pre-existing river valleys during the Ice Age, instances of which may be seen in several of the larger rivers. The singular phenomenon of a water-fall at the mouth of the St. John may be partly the result of the pre-glacial outlet being blocked up with till, and partly due to the subsidence of the region. The present outlet, which has been excavated through solid rock to a depth of about 110 feet, is post-glacial in origin. Prior to its formation, the pent up waters of the St. John must have spread over a very large area inside of the barrier and played an important part in the formation of terraces and lacustrine beds. There is reason to believe that during the subsidence which took place when the Leda clay was deposited, the sea invaded the St. John valley and lake region described, as far as the Keswick River, although no marine remains have yet been found above the Long Reach. Origin of water-falls and gorges.

All the rivers of New Brunswick, as already stated, flow over beds of drift which occupy their valleys, and are engaged once more in wearing them down from the high levels to which they were raised by the material thrown into them during the Ice Age. The fact of their flowing over stratified gravel, etc., in certain parts of their courses would Erosion carried on by rivers.

almost seem as if they were filling up instead of cutting down their channels, and locally this does occur to some extent even at the present day, but appears to have played a more important part in their history in early post-glacial times. There is, however, a constant wearing down, as well as a general seaward movement, of the materials of river valleys going on together.

Lakes and lake systems post-glacial. The lakes and lake systems are so intimately connected with the rivers that the two have necessarily to be considered together. But while we have abundant evidence of the pre-glacial existence of rivers or rather of river-valleys, we have none regarding lake basins. The latter, therefore, have to be studied as if they were solely of post-glacial origin. Nevertheless, that Tertiary lakes existed, or, at least, that the rivers then had somewhat similar sources of supply to those which now obtain, there seems no reason to doubt. The tendency of all lakes, however, is to cut down their outlets and thus drain themselves, and for this reason, few lakes, if any, may have existed, except on the water-sheds, at the close of the Tertiary period. But if the precipitation in this region and the drainage basin of each river were the same then as at the present day, the volume of water carried down during the year would be about the same also. If no lakes existed at their sources, however, the rivers would probably be lower in dry seasons from lack of a reserve supply, and higher during the season of greatest precipitation, and this alone would give them greater erosive power during floods. Their deeply cut rock-channels, and the fact that they nearly all flow over gravelly bottoms now, might be considered as arguing a greater pre-glacial precipitation and erosive action; but the extensive filling up of their valleys during the Ice Age produced changes which render it difficult to institute comparisons, even approximately correct, between pre-glacial and post-glacial drainage, as the rivers here particularly referred to have not had time since to clear out the drift from their valleys. From the traces of former high-water levels found along their banks, such as terraces and water-worn gravel, sometimes thrown into ridges or kames, it is obvious they must have flowed at different heights in the Quaternary period up to 150 to 200 above the present water courses along the larger rivers, and have probably held in lakes or lake-like expansions here and there in early post-glacial time.

Lake basins how formed. Elevations of lakes. The larger number of the lakes of the province are held up by barriers of drift or morainic materials, and their configuration and depth are largely the result of the denudation and arrangement of such materials by glaciers, as explained in my report already cited. The Nepisiguit Lakes, the most elevated in New Brunswick, being 996 feet above sea level, and 10 to 20 feet deep, have a general east and west direction, corresponding with the course the glaciers pursued in that part of the

country. Nictor Lake, 828 feet above the sea, and 50 to 60 feet deep, has the same trend longitudinally. Upsalquitch Lake is 792 feet above the same datum line, and 55 feet deep, its general direction, however, being north and south. These and the other lakes at the head of the Right Hand Branch of the Tobique River, are all evidently drift dammed, and are surrounded by high mountains and romantic scenery. Great quantities of trout (*Salmo fontinalis*) and fresh-water mussels (*Unio complanatus*), etc., are found in them, and the black duck (*Anas obscura*), the loon (*Colymbus torquatus*) and other species of water-fowl are also common there.

Rock-basins holding lakes, how formed.

Several small lakes, lying in rock-basins, occur in the Laurentian or Pre-Cambrian belt to the north of the city of St. John. Lily Lake, half a mile distant therefrom, occupying an area of 27 acres, 25 feet deep, and elevated 60 feet above sea-level is one; Howe's Lake, 145 feet high, is another; Dark Lake, 165 feet high, a third; also Lawlor's Lake on the site of the Intercolonial railway, and others. These lake basins have evidently been formed by the sub-aerial decay of the rocks *in situ* in Pre-Quaternary times, the softer limestones, graphitic shales and ferruginous rocks having been more deeply acted upon than the gneisses and felsites. During the Ice Age the *débris* was scooped out by the moving glaciers, leaving the depressions wherein lie the lakes. Glacial striæ are invariably found on the southern borders of these lakes, the ice having moved in a southerly direction in this part of the country.*

Caves.

Mr. G. F. Matthew informs me that he regards some of these lake basins as having originated from the formation of cavities in the Laurentian limestones through the agency of running water together with atmospheric decay along certain lines of the strata, the rock above the cavities afterwards falling in or breaking away, and the loose materials having been subsequently scooped out by glacier ice. Caves are still found in these limestones in the vicinity of St. John.

Origin of valleys and inequalities of surface.

The depressions occupied by river systems and also the larger number of lake basins are therefore the result mainly of the wear of the rocks from running water and unequal sub-aerial decay in their natural situation, chiefly in ages preceding the glacial epoch, the softer strata having thus been more deeply acted upon by the degrading influences mentioned. When the ice of the glacial epoch accumulated upon the surface of the country, a thick mantle of rock *débris* is supposed to have occupied the rock surface beneath it, which, becoming partially frozen into its bottom, would be moved along with

* For the theory here adopted regarding the sub-aerial formation of rock basins holding lakes, by the secular atmospheric degradation of rocks, glacial denudation, etc., see Dr. A. R. C. Selwyn, Geological Magazine, vol. IV., p. 94 (1877): R. Pumpelly, American Journal of Science and Arts, vol. XVII., Third series, p. 133 (1879); Dr. T. Sterry Hunt, ibid. vol. XXVI., Third series, p. 190 (1883), etc.

it, thus grooving and striating the rocks, breaking off the irregular knobs and projections which had not been so readily decomposed, and smoothing down to a large extent the asperities of rock surfaces. This moving mass would conform to the various inequalities of the surface over which it passed, scooping out the decayed rock material from many of the depressions formed by such unequal decay and forming hollows, sometimes rock-rimmed, but oftener partly rock-rimmed and partly enclosed by drift. On the retreat of the ice of the glacial epoch, the drainage of the areas surrounding these depressions, in most cases, would find its way into them, thus forming lakes. If the lake happened to be on a slope, the overflow became a river, following some pre-existing river-valley which, as stated on a previous page, would tend eventually to drain the lake by wearing down the outlet. When a lake occurs on a water-shed, however, although it has more than one outlet, it may have no extent of drainage area around it, and its overflow being insignificant, it will, in this country, where the precipitation is always in excess of the evaporation, usually remain full all the year round. The wearing down of the outlets from lakes on water-sheds is a very slow process, more especially if the drainage area around them is small, the outlets in that case being also small; and hence these will be the last lakes to lower their level or disappear, not only from the causes mentioned, but also from the fact that less sediment is carried into them.

Relation of lakes to drainage and precipitation.

In consideration of the facts above stated, therefore, it would appear that the present surface features of the province are largely the result of the operation of such agencies as are seen around us at the present day, augmented and intensified by the exceptional condition of things which existed in the glacial epoch. The "hills and dales," river valleys, lake basins and other depressions have been produced either by atmospheric degradation, or the wearing action of flowing waters, or both, and at the advent of the Ice Age the rock surface of the region must have presented very nearly the same contour as at present.

Glacial Striæ.

The following list includes all the striæ observed, so far as known, throughout the province, except those already recorded by Mr. G. F. Matthew (Report of Progress, 1877–78) and by myself (Report of 1882–83–84). Striæ have been noted in different places by Mr. R. W. Ells, Mr. Chas. Robb, Prof. Hind, and by the late Prof. Jas. Robb, which are embraced in this list and duly credited to them. Those given on the authority of Prof. Robb were obtained from a paper published in the Proceedings of the American Association for the Advancement of Science (1850). The courses are all referred to the true mer-

Striæ, by whom noted.

idian, and the direction of the ice-flow is indicated by the bearings in the proper column. Where doubt exists as to the course the ice pursued, the reverse one is also given, as in the case of Nos. 7 and 10. The "General Slope of Surface" is not to be understood as having any relation to the course of the ice-flow, but simply shows the general contour of the surface where the striæ occur. All the heights given have reference to sea level, unless otherwise stated.

No.	LOCALITIES.	COURSES.	GENERAL SLOPE OF SURFACE.	APPROXIMATE HEIGHT.
	ALBERT COUNTY.			
1	In Dawson sett., 5 miles N. of Hillsboro, (Ells.)	S. 54° E.		
2	At Hillside, 1½ miles S. of Turtle Creek, (Ells.)	S. 60° E.	N.	
3	On road from Curryville to Hopewell, near Shepody mountain.......... (Ells.)	S. 55° W.		
4	Three miles N. E. of Hopewell Hill. (Ells.)	S. 65° W.		
5	In Woodworth sett., 3 miles N.E. of Hopewell Hill................ (Ells.)	S. 65° W.		
6	At Hillside P. O., N. side of mountain, (Ells.)	S. 30° W.		
7	Three miles from Albert on road to Germantown Lake.............. (Ells.)	S. 80° W. or N. 80° E.		
8	At Mary's Point................ (Ells.)	S. 55° W.		
9	On road from Elgin to Golden mountain, 2 miles S. E. of Elgin Corner.. (Ells.)	S. 25° E.		
10	Four miles from Albert on road to Salmon River........................ (Ells.)	S. 80° W. or N. 80° E.		
11	Near shore at 1-Mile brook below Point Wolf......................... (Ells.)	S. 70° W. or N. 70° E.		
	CHARLOTTE COUNTY.			
12	At Beaver Harbor...........older striæ.	S. 54° E.		
	" " ....later striæ.	S. 89° E,		
13	At Back Bay, N. side..................	S. 54° E.		
14	Head of Back Bay.....................	S. 64° E.		
15	At Mascareen (apparently later and finer striæ) All these striæ cross the small valleys and fjords of the Bay of Fundy coast nearly at right angles	S. 89° E.		
16	Near Oak Bay .... (Robb)	S. 18° E.		
17	At St. Andrew's, sea shore....... (Robb.)	S. 28° E.		
18	Near St. Andrew's, on upland.... (Robb.)	S. 28° E.		
19	At Chamcook Lake.. .... (Robb.)	S. 48° E.		

No.	LOCALITIES.	COURSES.	GENERAL SLOPE OF SURFACE.	APPROXIMATE HEIGHT.
	CHARLOTTE COUNTY.—*Continued.*			
20	At L'Etang harbor..............(Robb.)	S. 63° E.		
21	Between St. George and L'Etang (Robb.)	S. 63° E.		
22	At Falls of Magaguadavic River (Robb.)	S. 65° E.		
	GLOUCESTER COUNTY.			
23	At Belledune, on Intercolonial railway, 1 mile E. of Belledune River. Grooves and striæ......	N. 82° E.	N.	170
24	Crossing these are fine, distinct, but irregular striæ, well preserved on both N. and S. sides of E. and W. *roches moutonnées*......	N. 3° W.		
25	In another place along railway track, a ¼ mile nearer the river, grooves and striæ......	N. 77° E.	N.	170
26	Cross striæ, fine, but distinct, are numerous here also. They are usually short and broken lines..........	N. 3° W.		
27	At Belledune station, grooves and striæ..	S. 88° E.	N.E.	100
28	Later and finer striæ.......... The grooves or ruts of the older set are 8 inches or more in depth, and from 6 inches to 2 or 3 feet wide. The later striæ are fine and irregular, sometimes running into each other, and appear on both sides of the larger and deeper E. and W. ruts.	N. 3° W.		
29	At Belledune, 1 or two miles behind railway station on low E. and W. ridge.	S. 88° E.	N.E.	200
30	At Elm Tree River, N. side along Intercolonial railway..........	N. 87° E.	N.E.	60
31	At same place, on S. side of river, 2 sets. Older set, grooves and scratches.....	N. 87° E.	N.E.	55
32	Later and finer set..........	N. 22° E.		
33	At Millstream, N. side, along railway, grooves and striæ..........	N. 42° E.	N.E.	50
34	At Nigadoo River, grooves, but not distinct..........	N. 40° E.	N.E.	
35	At Peter's River, (N. side of,) 3 miles N. of Bathurst, *roches moutonnées*, grooves, etc..........	N. 42° E.	N.E.	80
36	Tête-à-gauche River, (just N. of,) along railway. Grooving and fine striæ...	N. 22° E.	N. E.	75
37	At Bathurst Harbor, W. side of.........	N. 22° E.	....	Between tide marks.
38	In Ste. Louise sett., S. side of Nigadoo River..........	N. 77° E.	N. E.	

No.	LOCALITIES.	COURSES.	GENERAL SLOPE OF SURFACE.	APPROXIMATE HEIGHT.
	GLOUCESTER COUNTY—*Continued.*			
39	In same place, further north on N. and S. road........................	N. 72° E.	N. E.	
40	In same place, at N. end of last-mentioned road........................	N. 67° E.	N. E.	
41	In Robertville sett.; E. end of southernmost E. and W road	N. 72° E.		
42	In same place, at E. end of most northerly E. and W. road	N. 72° E.	N. E.	400
43	In Dunlop sett.; on N. bank of Peter's River, 2 sets. Older grooves and striæ	N. 57° E.	N. E.	185
44	Later and finer striæ.................. The earlier chiefly grooves, the later fine striæ	N. 77° E.	....	
45	At Bald Mountain, three miles above Indian Falls, Nepisiguit, or fifty miles from mouth of river. No distinct grooves nor striæ, but *roches moutonnées* and polishing.................. Boulders from the W. were seen on this mountain.	E. and W.	N.E.	1920
	KENT COUNTY.			
46	At Weldford Station, Intercolonial railway, and two miles S..	S. 3° W. or N. 3° E.	Flat.	250
47	Halfway between Weldford and Coal Branch Stations, in several places...	S. 5° W. or N. 5° E.	Flat.	275
48	At Cocagne beach, by Prof. Jas. Robb, 2 sets.......................Older / Later	N. 68° E. / N. 25° E.		
	KINGS' COUNTY.			
49	At mouth of Nerepis River......(Robb.)	S. 65° E.		
50	At Oxbow, or bend of Nerepis River (Robb.)	S. 50° E.		
51	In Nerepis settlement...........(Robb.)	S. 30° E.		
52	At Hardings, Nerepis River.....(Robb.)	S. 19° E.		
53	At Elmsdale, S. side of Long Reach (Ells.)	S. 75° E.		
54	At Belleisle Corner.... ....(Ells.)	S. 10° E.		
55	On road from Norton Station to Belleisle Corner, 4 to 5 miles out ....(Ells.)	S. 10° E.		

No.	LOCALITIES.	COURSES.	GENERAL SLOPE OF SURFACE.	APPROXIMATE HEIGHT.
	MADAWASKA COUNTY.			
56	Near Madawaska chapel.........(Robb)	S. 75° E.		
57	At Edmundston village, on left bank of St. John..............................	S. 65° E.	S.	600
58	In Madawaska valley, 3 miles from mouth of river, on right bank..............	S. 45° E.		
59	In same valley, about 2 miles from mouth of river, on left bank...............	S. 65° E.	N. W.	600
	NORTHUMBERLAND COUNTY.			
60	Along Intercolonial railway, 6 miles N. of Newcastle, and between that and Beaver Brook station..............	S. 23° W.	Flat.	300
	These striæ are within the drainage basin of the Miramichi on a southward slope.			
61	Near same place, another set...........	S. 18° W.	Flat.	300
62	Two miles N. of Beaver Brook station, on right bank of Green Brook..........	S. 87° E.	Flat.	350
	Striæ in last two places not very distinct; no grooves.			
63	At Blackville, central part, along road, on W. side of S. W. Miramichi.........	N. 68° E.	Flat.	
64	At confluence of Indiantown Brook with S. W. Miramichi....................	N. 73° E.	Flat.	50
	Deep grooves and fine striæ, both in same direction.			
65	At the mouth of Hay's Brook, 8 to 9 miles above Boiestown, along right bank of S. W. Miramichi...........	N. 38° E.	N. E.	480 ?
	Striæ, distinct and well defined.			
66	At Rogersville station, Intercolonial railway, 2 to 3 miles N. of..............	N. 83° E.	N. W.	225
	QUEEN'S COUNTY.			
67	At Bupel's Cove, Grand Lake....(Robb).	S. 30° E.		
	RESTIGOUCHE COUNTY.			
68	At New Mills, near Intercolonial railway, in several places, *Roches moutonnées* and grooves................	N. 82° E.	N.	25–50
69	At Benjamin River, S. of, on post road..	S. 83° E.	N.	
70	One to two miles E. of Charlo River, along main road...................	N. 82° E.	N.	

No.	LOCALITIES.	COURSES.	GENERAL SLOPE OF SURFACE.	APPROXIMATE HEIGHT.
	RESTIGOUCHE COUNTY—*Continued.*			
71	At same place, on McPherson's farm.. One groove here in trap rock is 7 feet wide.	N. 82° E.	N.	35
72	At same place, N. branch of river, on second concession road............	S. 83° E.	N.	125
73	In Dundee settlement..................	N. 77° E.	N.	225
74	In same place, near W. end of settlement, 2 sets.......... { Older..	N. 77° E.	N.	325
	{ Later..	S. 68° E.	N.	
75	Two miles W. of town of Dalhousie, at intersection of branch railway with road..........................	N. 67° E.	N.	80
76	Along Dalhousie branch railway, 2 miles from Junction.....................	N. 72° E.	N.	200
77	On Lily Lake road, near Campbellton, 1½ miles from lake..................	N. 77° E.	N.	500
78	On same road on same side of hill, but nearer lake......................	N. 67° E.	N.	575
79	On same road on summit of hill........	N. 67° E.		600
80	On same road on southern side of summit................................	N. 67° E.	S. W.	550
81	On road to Parker's Lake, 3 miles from town of Campbellton, on N. side of a ridge running E. and W...........	N. 67° E.	N.	500
	ST. JOHN COUNTY.			
82	At E. end of Courtenay Bay, near glass works...............................	S. 5° W.	N. W.	Tide Level.
83	At E. end of Courtenay Bay, near old burying-ground....................	N. and S.	N. W.	10
84	On W. side, at foot of Elliott row, St. John city......................... These striæ have a difference of 5° in their course on the E. and W. sides of Courtenay Bay, showing effect of uneven surface upon the ice-movement.	N. and S.	E.	Tide Level.
85	In Carleton, St. John, N. corner of public square..........................	S. 2° E.	N.	20–30
86	In Portland, St. John..................	S. 15° E.	S.	75
87	In Portland, at outlet of Lily Lake......	S. 10° E.	S.	60
88	In Portland, on road behind Reed's castle	S. 10° E.	S.	
89	At Dark or Crescent Lake...............	S. 20° E.	S.	165
90	At Spruce Lake........................	N. and S.		175
91	At Sutton's Mills, 4 miles W. of St. John harbor...............................	S. 20° E.	N. W.	20–30

No.	LOCALITIES.	COURSES.	GENERAL SLOPE OF SURFACE.	APPROXIMATE HEIGHT.
	ST. JOHN COUNTY.—*Continued.*			
92	Near St. John, at brick.yard,.....(Robb.)	S. 20° E.		
93	At penitentiary, E. side of Courtenay Bay.......................(Robb.)	S. 10° W.		
94	At South Bay..................(Robb.)	S. 5° W.		
95	At Musquash Mills.............(Robb.)	S. 38° E.		
96	E. of Musquash River ....(Robb.)	N. and S.		
97	At Hunter's Ferry, Quaco Lake..(Robb.)	S. 32° E.		
	SUNBURY COUNTY.			
98	At Rushiagonish bridge........(Robb.)	S. 28° E.		
99	Near Gagetown, at old mill......(Robb.)	S. 40° E.		
100	Near Gillon's, Blissville or Nerepis Road. (Robb.)	S. 28° E.		
101	Two miles S. of last place.......(Robb.)	S. 28° E.		
	VICTORIA COUNTY.			
102	On Blue Mountains, Tobique River, (Hind.)	N. and S. to S. 20° E.		1650
	WESTMORELAND COUNTY.			
103	At Dorchester, on ridge behind penitentiary.............................. Grooves in places. Ice moved up N.W. face of an escarpment following Memramcook valley.	S. 12° E.	W.	175
104	At Jolicœur, Hall's Hill, polishing and *roches moutonnées*....................	S. 20° W.	N.	110
105	At Aulac, near Fowler's hill............ Ice-movement here was guided by Cumberland Basin and Westmoreland Ridge.	S. 38° W.		80
106	At Cape Tormentine, on Emigrant settlement road, 5 miles from Port Elgin. (Ells.)	S. 2° E.		
107	At Cape Maringouin, near point on E side. (Ells.)	S. 2° E.	E.	
108	Near Sackville, 1 mile S. of Intercolonial railway on road to Maringouin..(Ells.)	S. 12° E.		
109	Five miles N. E. of Dorchester, and 2 miles from Intercolonial railway......(Ells.)	S. 12° E.		

No.	LOCALITIES.	COURSES.	GENERAL SLOPE OF SURFACE.	APPROXIMATE HEIGHT.
	WESTMORELAND COUNTY—*Continued.*			
110	On road from Sackville to Dorchester Copper Mines, 4 miles N. W. of Sackville, 2 sets.................(Ells.)	S. 12° E. S. 3° W.		
111	In second Westcook settlement at forks of road.......................(Ells.)	S. 13° W.		
112	On E. side, one mile from Westcook church on road going up hill...........(Ells.)	S. 12° E.		
113	Dorchester, 1½ miles S. of, or ½ a mile S.W. of railway crossing on road going to Cape Maringouin, W. side............(Ells.)	S. 22° E.		
114	At Fairfield, 3 miles E. of Dorchester (Ells.)	S. 6° E.		
115	At Memramcook Corner, 2 miles E. of, on highlands.......................(Ells.)	S. 26° E.		
116	At Boudreau quarry, on road from Rockland to Boudreau, 2 sets...... (Ells.)	S. 12° S. S.		
	YORK COUNTY.			
117	At St. Mary's, near Fredericton ..(Robb.)	S. 30° E.		
118	Four miles N. of Fredericton.....(Robb.)	S. 30° E.		
119	Near Maryland ....(Robb.)	S. 30° E.		
120	At Dyer's on Hanwell road......(Robb.)	S. 30° E.		
121	On old Woodstock road..........(Robb.)	S. 30° E.		
122	At Springhill ....(Robb.)	S. 30° E.		
123	Near French Village.............(Robb.)	S. 30° E.		
124	On hill beyond Indian Village ..(Robb.)	S. 30° E.		
125	Near Naylis' on Royal road .....(Robb.)	S. 33° E.		
126	At Cardigan settlement..........(Robb.)	S. 18° E.		
127	At S. end of Oromocto Lake.....(Robb.)	S. 18° E.		
128	In Harvey settlement..... .....(Robb.)	S. 20° E.		
129	At Hanwell school house, 2 sets..(Robb.)	S. 28° E. S. 63° E.		

No.	LOCALITIES.	COURSES.	GENERAL SLOPE OF SURFACE.	APPROXIMATE HEIGHT.
	YORK COUNTY.—*Continued.*			
130	Near W. end of Oromocto Lake . . (Robb.)	S. 48° E.		
131	At mouth of Keswick . . . . (Robb.)	S. 48° E.		
132	In parish of Prince William . . . . . (Robb.)	S. 28° E.		
133	At Fredericton . . . . (Hind.)	S. 30° E.	. . . .	350
134	Four miles out on Miramichi road . . . . (Hind.)	S. 20° E.	. . . .	400
135	On Hanwell road . . . . (Hind.)	S. 30° E.	. . . .	400
136	On Maryland road in three places . (Hind.)	S. 30° E.	. . . .	400
137	In Prince William, near antimony mines . . (Hind.)	S. 20° E.	. . . .	400
138	On Gagetown road . . . . (Hind.)	S. 20° E.		
139	In Harvey settlement . . . . (Hind.)	S. 20. E.		
140	Opposite Fredericton . . . . (Hind.)	S. 30° E.	. . . .	350
141	On road at N.W. corner of Oromocto Lake, 2 sets . . . . (Chas. Robb) { older / later	S. 30° E. S. 50° E.		
142	On road from Fredericton to Erina Lake, 2 sets . . . (C. Robb.) { first . . . / second	S. 40° E. N. and S.		
143	In Bird settlement . . . . (C. Robb.)	S. 45° E.		
144	In Tay settlement . . . . (C. Robb).	S. 38° E.		
145	Below Fredericton . . . . (C. Robb.)	S. 30° E.		
146	At forks of Nashwaaksis . . . . . (C. Robb.)	S. 35° E.		
147	North of Lake George, in two or three places . . . . (C. Robb.)	S. 30° E.		

M 1. Till, or Boulder Clay, Moraines, etc.

Till is but rarely met with on the surface in the northern part of the province, but usually appears along banks of rivers and in bluffs on the coast of the Baie des Chaleurs, affording evidence from its sheet-like character that it extends under the stratified deposits in an almost continuous bed of greater or less thickness. The heaviest deposit of till known in this district occurs on the coast just north of Nash's Creek, where it attains a thickness of fifty to sixty feet. Another ridge-like mass of till is met with on the left bank of the Nepisiguit River, through which the Intercolonial railway passes by a cutting, showing it to be composed largely of granitic and red sandstone *débris* (local rocks). Distribution of till in northern New Brunswick.

Till occurs on the left bank of Nigadoo River at the shore, and is overlaid by stratified beds. It is also seen on the banks of the Tête-à-gauche River, near the Dunlop settlement road. A high bank of till is seen in a cutting on the Intercolonial railway, on the right bank of the South-West Miramichi. Glaciated boulders of granite, felsite, diorite, etc., from the belt of crystalline rocks to the west, occur in this deposit.

Another ridge of till is met with on the left bank of the Petitcodiac River, behind Moncton, in a cutting of the Intercolonial railway. At Moncton.

At St. John a great mass of till lies on the west side of the harbor, forming a headland known as Negrotown Point, which extends southward from Carleton. At St. John.

Heavy deposits of till occupy the St. John valley above Grand Falls, as referred to in my last report, forming banks and mounds along the river as far up as St. Leonard's and above it. The village of Edmundston stands upon a bed of till, and the same material occurs abundantly in the Madawaska valley, having been much less eroded along the upper St. John and its tributaries than below Grand Falls. Along the St. John River.

Along the St. John River from Grand Falls to Andover, and indeed as far south as Woodstock, a ridge, or series of ridges, chiefly of till, which occasionally assumes the appearance of mounds, is traceable. A portion of it has been described in my report already cited, under the head of "Kames."

At St. Croix village, York county, and also on the opposite side of the St. Croix River, at Vanceboro, similar ridges occur. The one on the New Brunswick side is 300 paces wide and 50 to 60 feet high above the river, and appears to be some miles in length. Portions are stratified and kame-like. At St. Croix.

At the head of the Magaguadavic River, low, wide ridges, chiefly composed of till, are also met with.

Irregular thickness of beds of till.

In some cases these deposits of till rise above the general level, as appears in railway cuttings passing through them transversely; in other cases they are merely the edges of the sheet which spreads over the surface of the country, but which must have been much thicker in river valleys and depressions than on the higher levels.

Its occurrence along river banks.

How is it that accumulations of till, resembling ridges, occur along or near the banks of many of the New Brunswick rivers? Has it been moved about and thrown into these moraine-like ridges by moving river ice during spring floods, when the rivers in the early Post-Tertiary period flowed at a higher level than now? Ridges have evidently been formed in this way in the same situations during the recent period, and shallow lakes are found in some localities with similar ridges around their borders. The latter are, however, in most cases, partially stratified.

On the uplands of the interior of the province, till can be seen almost everywhere forming the lowest member of the surface deposits, but usually thinning out on the elevations, and perhaps disappearing, except locally, on hills and mountains. Accumulations of considerable thickness occur on the slopes, and more especially at the base of the hills and around the borders of lake-basins.

Moraines.

Moraines are met with in all parts of the province, but are not so numerous anywhere as on the water-shed between the St. John River and the Bay of Fundy, especially in York and the northern part of Charlotte counties. In Nictor Lake, one was seen forming a small islet, and another occurs at the western end of the upper Nepisiguit Lake, forming a promontory which is covered by a grove of red pine; also along the Nepisiguit valley small moraines were observed in several places. One at the Devil's Elbow, fifty-five miles from the mouth of the river, stands up in the centre of the valley, kame-like, but is probably underlaid by rock.

KAMES.

Classification of kames.

In classifying the kames of western New Brunswick in the report on the surface geology of that region (Report of Progress, 1882-83-84), two principal divisions of these deposits were made. It becomes necessary now to add a third, as explained on a previous page, which will include all those gravel ridges, mounds and hummocks which appear to have been under the sea and partly, at least, remodelled by marine currents. A number of these occur in a well developed condition on the coast of the Bay of Fundy,* and a remarkable one is found in Restigouche county along the bank of the Baie des Chaleurs. Three

* See Report on the Superficial Geology of Southern New Brunswick, by Mr. G. F. Matthew, 1877-78.

divisions or classes of kames will, therefore, be treated of:—(1) those on the higher levels, at the sources or along the upper part of rivers and around lake basins, and which are not confined within narrow valleys, but have usually swampy or peaty grounds on one or both sides; (2) those found in narrow river-valleys which are usually enclosed by high slopes or hills; and (3) kames partly or wholly of marine origin, which appear to be composed of material derived either from pre-existing beds of till along the coast margin, or of gravel, etc., carried down by rivers during that part of the Quaternary epoch when the land stood 150 to 200 feet below its present level relative to the sea. Three divisions of kames.

In the following brief description of the kames examined during the season of 1884, all the courses given are referred to the true meridian, and the heights to sea level. Description of kames.

KAMES OF CLASS I.

1. A kame is seen crossing the highway between Kouchibouguac River and Chatham, at Lake settlement, on the right bank of Little Black River, near its source. Length unknown, the district being wooded; course, nearly east and west; height above general level, 10 to 20 feet; above sea level, probably 150 feet.

2. On the left bank of a small stream (the head of a branch of Portage Brook, a branch of the N.W. Miramichi,), about four miles south of Bartibogue station, Intercolonial railway, a small kame crosses the track; course, about east and west; length unknown; height above sea level, 500 feet.

CLASS II.

3. A kame, or elongated mound, occurs at the Devil's Elbow, Nepisiguit River, which is probably morainic to a large extent; course, nearly east and west, or parallel to the valley; length about one-fourth of a mile; height above the river, 50 to 75 feet, above sea level, 650 feet.

4. Several short, broken ridges (kames), are found at the confluence of the Taxis and South-West Miramichi Rivers, their general course being parallel to the last-mentioned river; height above its surface, 10 to 15 feet.

5. Along the Tobique River, on right bank, between Arthurette and Three Brooks, a number of hills occur in the valley, which are left from erosion of the surrounding deposits. They consist of sandstone beneath, and drift on the summits, chiefly water-worn gravel. Height, 75 to 100 feet; general longitudinal course, parallel to the river. Some of these hills are angular in outline, and there has evidently, been a channel on the west side in early post-glacial times.

6. Opposite the mouth of the Odell River, a branch of the Tobique, a hill stands upon the right bank, apparently in the middle of the Tobique valley. It is composed chiefly of rock, with gravel on the summit and lower end, and is evidently a mass of red sandstone and drift left from denudation.

7. At Gagetown, Queen's county, a mound occurs in the St. John valley. It is composed largely of glacial drift, with water-worn materials on its summit. General course parallel to the river. A marshy flat surrounds it.

8. Mounds or short ridges of gravel occur on the left bank of the Petitcodiac River, at Boundary Creek, along the west side of the Intercolonial railway. A gravel pit has been opened in a terrace here. These mounds are not more than 40 to 50 feet above the river, which is tidal up to this point.

9. A short, low, kame or hummock, 200 to 300 yards long, occurs on the left bank of Memramcook River, just above the angle formed by it and the second stream flowing into it north of Dorchester Corner.

10. Near Hillsboro', Albert County, on the marsh skirting the Petitcodiac River, a kame, called "Gray's Island," occurs. General direction N.E. and S.W.; height, above tide level in Petitcodiac River, 35 feet; length 700 paces, width 220 paces. It is composed of sand and gravel, with small rounded boulders, almost wholly derived from Lower Carboniferous rocks. Being surrounded entirely by salt marsh, it is a conspicuous example of a part of a terrace left from the denudation of the materials around it, of which it formed a part.

Class III.

11. One of the longest and most remarkable kames of this group occurs in Restigouche county along the coast of the Baie des Chaleurs, stretching from the Eel River valley to the shore just north of the mouth of Nash's Creek. Length about twelve miles; course nearly east and west; height above the sea at the western end 150 to 175 feet, and at the eastern end 50 to 75 feet. It is intersected by streams in many places, and overlaid by Leda clay and Saxicava sand, the materials of which are often derived from it. This kame runs pretty close to the shore of the bay, except at Charlo and Eel Rivers, receding from it into the second concession, at Shannonvale, and in Dundee settlement appears on both branches of Eel River in the form of hummocks, which abut against the higher ground to the north-west. In the neighbourhood of River Charlo the shoreward side is terraced. The materials of this kame are almost wholly derived from local rocks, and seem to have been first carried down to their present situation by currents from the land, and afterwards partially worked over by the sea.

12. Along the coast of the Bay of Fundy there occur a number of kames of this class, which have been tabulated and described by Mr. Matthew (Report of Progress, 1877-78), but the elevations above sea level were not given. One, extending from Fairville, St. John county, southward nearly to Spruce Lake, and called by Mr. M. the "*middle ridge in Lancaster*," was found to be 175 feet high at the northern end, and 130 to 140 feet at the southern. It is a wide,

flat-topped ridge of gravel and boulders, overlaid by marine deposits, the materials of which seem to have been derived from beds of till in the vicinity, and has been remodelled by the combined action of fluviatile and marine currents along the coast when the land stood at a lower level. In its external features this kame is altogether unlike those of the interior.

13. The extensive gravel deposit known as Pennfield Ridge, Charlotte county, (No. 17 of Mr. Matthew's table) occupies part of the valley or basin between the Magaguadavic hills on the north and those extending along the coast from L'Etang to New River. It appears to be only partially stratified, but is terraced. Height, 175 to 200 feet.

Theories regarding the formation of kames.

The origin of kames, which is one of the vexed questions of surface geology, still continues to be a fruitful source of discussion. Various theories have been advanced to account for them, and the literature of this subject alone is quite voluminous. A study of these phenomena in the Maritime Provinces of Canada for many years has convinced the writer that it is useless attempting to explain all kames as originating from any one general cause, such, for example, as glacial floods, the action of marine currents, etc. On the contrary, I am inclined to regard their formation as due to several causes, which may be, to a large extent, local, arising from peculiarities in the conformation of the land-surface affecting the drainage within certain areas at the close of the glacial epoch and since, and also to marine currents, such as those in the Bay of Fundy, acting upon the drift along the coast line, or that carried down by rivers. I have, therefore, thought it best to arrange the kames met with in New Brunswick into three classes as already mentioned. The probable mode of origin of those included in classes II. and III. has been briefly outlined. It is only those belonging to class I. which present the difficulties referred to, and, in the present state of our knowledge, no satisfactory theory regarding them seems possible. They are, undoubtedly, to a considerable extent, morainic, these and moraines, to all appearance, having been of contemporaneous formation; but, on the other hand, the fact that they occur, so far as my observations have extended, along the heads of streams where there are dead waters, or on the borders of lakes, not being confined within narrow valleys, and usually with swampy or peaty areas on one or both sides, and, moreover, have tortuous courses resembling those of rivers, leads to the conclusion that the streams along which they are found must have, in early post-glacial times, participated in their formation, although the precise mode of action is not evident. Additional data and a closer study of these very interesting phenomena will, no doubt, reveal to the student some general law respecting their origin; all that can be done, meantime, is to collect and correlate the facts bearing upon them.

General Conclusions Regarding the Glacial Phenomena of New Brunswick.

Glaciation of the province.

From the foregoing facts with reference to striæ, till, transported boulders, etc., it is evident the whole area of the Province must have been mantled by an ice-covering in the earlier part of the Quaternary epoch which, by its movement seaward, scarped and scoured the surface, transported drift, and produced marked changes in the physical features, more especially with respect to its drainage. Whether this ice mantle formed one glacier, or a number of smaller local glaciers, each moving as it was influenced by the contour of the land, I will not undertake to say from the data on hand; but the latter view is certainly supported by the greatest amount of evidence. As already stated, two principal and apparently independent systems of glaciation seem to have prevailed, one southward from the principal water-shed of the province, and the other northward. Besides these, however, there have been later ice-movements as evidenced by finer striæ, whether from local glaciers controlled more by minor inequalities of the surface than the larger glaciers, indicating that ice may have slid down the slopes more directly into the nearest depressions, or by icebergs impinging against the coast area when the land stood at a lower level, is doubtful, although certain facts, in connection with the striæ produced, favor the former conclusion. The evidence relating to these later ice-movements, it may be stated, is found chiefly on the northern slope, where the fine striæ with a more northerly course than those of the chief ice masses occur. On the Carboniferous area these markings of the later ice are not very distinct nor regular; but on the slates and crystalline rocks of the Baie des Chaleurs district they are well defined and numerous. They occur in many places on the same rocks as the older striæ and cross the deep wide glacial grooves of the latter going down one side, across the bottom and up on the other side of these, the slope of the land here being northward towards the Baie des Chaleurs basin. In a few cases they were seen to run into each other, but, on the whole, are regular and parallel over areas of many square miles, the direction being towards some point between north and northeast. The ice which produced them, whether small glaciers moving northward or icebergs drifted against the ascending surface of the land, evidently transported but little drift material. The great denuding and transporting agents were the principal ice-masses which moved southeastward on the main southern slope, and northeastward on the northern slope.

Two systems.

Evidence of later ice-movements.

Local glaciers.

On the isthmus of Chignecto there appear to have been local glaciers formed on the higher grounds, which crept down the valleys into the

Bay of Fundy, or rather into Shepody Bay and Cumberland Basin; or icebergs have passed over it during the Quaternary depression, grating the more prominent ridges. Very little foreign drift is met with here however. (See table of striæ, Nos. 103 to 116.)

General sequence of events during Ice Age.

The general sequence of events in the region now constituting the province during its occupation with ice seems, therefore, to have been somewhat as follows:—

(1) The accumulation of a mass of ice on the surface of the country, from what causes will not here be discussed.

(2) The movement of this ice from the higher interior region (in other words, the shedding of this ice by the principal water-shed), towards the coasts of the Bay of Fundy on the one hand, and the hydrographical basin of the St. Lawrence, or the depressions now occupied by the bays and straits connected therewith, on the other. This movement was accompanied by a great transportation of drift, or decayed rock-material, which had been formed on the surface previous to the Ice Age. River valleys were partly filled, and the rivers themselves dammed up. Lake basins were formed, not, so far as the evidence goes, from erosion of the rocks by the grinding power of the ice, but by (*a*) the scooping out of loose materials from hollows in rock, thus forming rock basins, and (*b*) by leaving depressions in the drift occupying pre-existing valleys which afterwards caught the drainage of the areas surrounding them.

(3) On the melting and breaking up of this ice-covering, either smaller ice-masses have slid down the slopes more directly towards the low marginal areas, or into the adjoining seas; or, as the land sank, icebergs may have grated the slopes, especially of the northern and eastern coast areas of the province.

Height of land during Ice Age.

At what height the land stood relatively to the sea during its occupation with this ice-covering does not seem possible to determine with any approach to accuracy from the data at hand, but as the rocks are everywhere striated down to sea-level, and in a few cases below it, and moreover as the depressions now forming estuaries, bays and straits seem to have influenced the movement of the ice, such for example as the estuary of the Restigouche, the western half of the Baie des Chaleurs, Nepisiguit Bay, Shepody Bay and Memramcook estuary, Cumberland Basin, etc., the land must have been as high as at the present day, if not higher during the period referred to.

Inferences respecting ice-movements.

In regard to the ice movement of the glacial epoch in New Brunswick one or two inferences may be drawn, and these are:— 1. That ice will flow down low inclined surfaces even if obstructed by hills and ridges as high as the ground which gave it momentum, provided there are valleys or passes by which it can creep through

to a still lower level. The principal water-shed in New Brunswick is a comparatively low one, the average descent or slope from it to the waters of the Gulf of St. Lawrence being about 14 to 15 feet a mile, while on the southern side, towards the Bay of Fundy, the slope is only 6 to 7 feet a mile. The direct descent, *i.e.*, in a straight line, from the higher portion, however, towards the Baie des Chaleurs is 25 feet a mile, towards Miramichi Bay 12 feet a mile; on the southward slope, from the higher elevation to the Bay of Fundy, it is only about 9 feet a mile. The ice in its southward flow from this water-shed was intercepted (1) by the St. John valley, out of which it had sufficient momentum to rise; (2) by the minor water-shed, between that valley and the Bay of Fundy, which it also surmounted, and (3) by the hills along the coast in Charlotte county and southern Kings. Notwithstanding these obstacles, it seems to have pursued an almost direct course from the grounds of the interior to the Bay of Fundy, crossing valleys, creeping through ravines and gorges, and passing over the small fjords on the coast nearly at right angles thereto. This latter feat it was, of course, the better enabled to perform from the momentum it received from the minor water-shed referred to.

Slopes of surface affecting ice-movements.

Whole surface of rocks not glaciated.

2. Although it has been generally supposed that ice scored the whole surface of the rocks beneath it by the movement of the rock *débris* which, partly frozen into it, formed its basal portion, yet there are areas which do not seem to have been scraped or grooved, the decayed rock material lying upon the solid rocks apparently undisturbed. Proofs of this can be seen along the southern side of the Baie des Chaleurs, between Bathurst and Caraquette. In certain places along this coast, especially at Clifton, where bold cliffs present good sections, the undisturbed material alluded to is found overlaid by what appears to be till, while the surface is strewn with transported boulders derived from the Pre-Cambrian and other rocks of the interior to the west. Similar phenomena were observed also in other places.

Probable thickness of Quarternary ice-covering.

3. The thickness of the ice, even when the glacial period had attained the maximum degree of cold, cannot have been very great. In the Restigouche estuary, striæ are found on the side of a hill facing the valley, 600 feet above sea level. Here the ice may have been 900 to 1,000 feet thick,—a less thickness would not explain the facts—and it probably did not much exceed this in any part of the province. The fact of its having enveloped mountains 2,000 feet high in the interior does not require that it should be much thicker, because it would necessarily have a slope on the surface corresponding with the slope of the country from there down to the marginal area.

M 2. Stratified Interior or Fresh-water Deposits.

The sand, gravel and clay beds described under this head are those overlying the till and intermediate in age between it and the alluviums of fluviatile and lacustrine origin. They comprise the gravels and other deposits forming terraces along river valleys and around lakes, which although partly belonging, in some places, to the recent deposits, especially the loamy portion covering many of the intervales, are, nevertheless, supposed to be mainly deposits contemporaneous with the Leda clay and Saxicava sand of the coast series. In other words, while the terraces belong to Division M 2 of our classification, the intervales or lowest terraces periodically overflowed by freshets belong to the alluviums or Division M 3. Reference will also be made to the deposits of stratified sand, gravel, etc., on the higher levels, and their probable origin explained. **Position of these beds in the series**

The terraces of the St. John valley and its tributaries were pretty fully described in my last report already referred to, and it will, therefore, be unnecessary to notice them in detail here. Those of other rivers in the province were examined however, among which were the Restigouche and its affluent the Upsalquitch, the Nepisiguit, North-West and South-West Miramichi, etc. Along these, terraces of greater or less dimensions occur in endless variety of form, some of them very beautiful and affording a considerable breadth of rich soil, but none can compare in elevation and extent, nor in picturesque shapeliness, with those along the main St. John. **Terraces of river valleys.**

A brief description of the terraces of several of those rivers will now be given by way of comparison with those occurring in the St. John valley, described in the above mentioned report. (Report of Progress, 1882-83-84.)

In the Restigouche valley, no terraces were observed more than 50 to 75 feet in height above the river at the nearest point. They are, however, of considerable area, occurring chiefly below the mouth of an affluent or a bend in the river. **Along Restigouche.**

The banks of the Upsalquitch have a considerable width of intervale and terrace land. Generally speaking, none of the terraces exceed a height of 30 to 40 feet above the river, and all have a slope down stream corresponding to it. At the upper falls, just above the mouth of Ramsay's Brook, there is one, however, which seems to have been formed under exceptional conditions, the result of a lake-like expansion of the river which formerly existed above this point. It is 65 feet higher than the river at the upper end of the falls. **Upsalquitch.**

Along the Nepisiguit also, there are numbers of low terraces,—one observed at the Grand Falls on the left bank being probably the highest. **Nepisiguit.**

It is 65 to 70 feet above the river at the upper basin, and consists of gravel underneath, mixed with cobble stones, and capped by a few feet of loam. Area unknown, but apparently limited.

North-West Miramichi.

On the North-West Miramichi no terraces of any consequence are met with till we reach the head of the tide at the confluence of the Little South-West. On both sides of the mouth of the latter stream extensive terraces occur, that on the right being 75 to 80 feet in height above tide level and covering an area of two square miles or more extending up the river some distance. It is composed chiefly of sand, but becomes coarser as we proceed up stream. A lower terrace, 30 to 40 feet in height, and another 18 to 20 feet, lie between it and the point of junction of the two rivers mentioned, the surfaces of which are partially covered with loam. Other terraces were seen along the Little South-West for six or seven miles up, which are of much coarser materials.

Along the main North-West above Red Bank, as far as Chaplin Island, terraces of considerable width occur on both sides. The highest on the left bank was found to be 75 to 80 feet above tide-level, and probably 50 to 60 feet above the river at the nearest point. Lower ones intervene, one of which measured 65 feet in height above tide-level.

The highest of these terraces have probably been formed when these parts of the river valleys were estuaries, with the land 80 to 100 feet below its present level, and the deposits are really marine or estuarine, although deriving their materials from the rock *débris* above which has been carried down by the rivers. The boulders are of granite, gneiss, felsite, diorite, slate, etc., all belonging to rocks of the interior.

South-West Miramichi.

On the main South-West Miramichi, terraces are not seen either till we reach the head of the tide, or confluence of Renous River. Above that they skirt the valley everywhere, but are not high, seldom exceeding 30 to 40 feet above the level of the river at the nearest point. Sometimes three are seen together, one rising above the other, but oftener only two. At Doaktown and the mouth of Taxis River they attain a considerable breadth, and when cleared afford excellent soil. At the latter place mounds or river-valley kames occur.

Petitcodiac.

The Petitcodiac River has some low terraces flanking it which are seen at Boundary Creek (where a gravel-pit has been opened in one), and at Salisbury and Petitcodiac villages.

Tobique.

The valley of the Tobique River exhibits many beautiful terraces as far up as the confluence of the Mamozekel and Right Hand Branch. One was seen immediately above the "Narrows" on the right bank at a height of 40 feet, and a second irregular one somewhat higher. These are lacustrine and have been formed when the river was dammed back by drift and held in a lake. At the foot of the Red

Rapids there are wide intervales on the right bank, composed of gravel, which have a height above the Tobique of 20 to 30 feet. At the mouth of the Wapskehegan, low terraces occur on both sides, that on the right being called "Wapske Flat." At Blue Mountain bend and the mouth of Riley Brook, similar low terraces skirt the river; while at the "forks," a terrace, 5 to 8 feet high and a mile long or more, runs along the left bank, which, at the lower end, is backed by another rising 30 to 50 feet above the river. On the Little Tobique or Nictor Branch a few narrow terraces are seen at intervals, the heights of which are 20 to 40 feet, becoming higher, however, as we approach Nictor Lake, the source of the river. Near the mouth of Cedar Brook, they are 50 to 60 feet above the stream, the valley being constricted there.

On Salmon River, an affluent of the St. John, a few miles above the Tobique, noteworthy and peculiar terraces occur at Upham's mills, three miles from its mouth, two of which are short ones, resembling artificial embankments. None exceed a height of 40 feet above the stream. Ridges of slate rock were seen to underlie some of them. **Salmon River.**

At the mouth of Madawaska River, a series of terraces occurs around the site of Old Fort Edmundston, the two highest of which are respectively 65 to 70 feet and 85 to 90 feet above the St. John, at the confluence of the two rivers. A drift-dam seems to have existed across the mouth of the Madawaska River in early post-glacial times, forming a lake or lake-like expansion above, which has been instrumental in carving out the terraces referred to. The St. John valley above this point becomes constricted and, as stated in my previous report, a lake has probably stretched from here to the Grand Falls immediately at the close of the Ice Age and before the remodeling of the drift into terraces began. The latter lake must have held in a body of water, the surface of which was 90 to 100 feet above the present level of this part of the St. John. **Madawaska.**

No terraces of any consequence were seen along the Madawaska River as far as the Quebec boundary, but extensive intervales indicate a lake bottom.

Some of the narrow terraces bordering the St. John valley between Grand Falls and Edmundston appear to have been formed by the material washed down from the slopes above them into the lake, which is supposed to have once occupied it, thus forming a bank under the surface along its margin while it remained at its highest level, the summit of which would be levelled off by the action of the lake waters. Atmospheric agencies of this kind alone seem to afford a reasonable explanation of the origin of several terraces in this locality, as they are not near the mouths of tributary streams, and the river valley here is a mile or more wide. **Peculiar formation of some terraces in valley of Upper St. John.**

Relation of terraces to the drainage, and size of rivers.

A somewhat detailed investigation of river-terraces in New Brunswick, shows that these formations bear a close relation to the drainage area surrounding them, to the size and depth of the valley, the volume of the river, etc., along the banks of which they are found. The larger rivers, especially when they flow through deep valleys, have invariably the largest terraces and *vice versâ*. The correspondence is so marked that it is comparatively easy to judge, from the size of the river, what the height of the terraces is, the relation apparently holding good not only at the present day, but evidently during all post-glacial time.

Conclusions respecting the origin of terraces.

In my report on the surface geology of western New Brunswick, already several times cited, a theory in regard to the origin of these terraces was tentatively advanced, and a further study of them during the summer of 1884, has brought out the following facts and conclusions, all tending to support it, viz.:—(1). Terraces are usually short, even the highest and longest seldom exceed two or three miles, and they have almost invariably a longitudinal slope corresponding to that of the rivers; (2), the highest terraces, while often having corresponding ones on the opposite side of the river, at about the same level, are, generally speaking, without it; and moreover, each terrace, except in a few cases, seems to have been formed separately and independently; (3), their greater development below the mouths of tributaries and constrictions and bends in the river valleys, and where the flow is most rapid, is a characteristic feature; and (4), their heights, relative to the rivers, are greater where the valleys are narrowest and deepest, and lowest where these are widest.

Erosion.

The data at hand seem, therefore, to lead to the conclusion that the larger number of terraces, along river-valleys, have been formed by the rivers eroding and modifying the drift which occupied these valleys at the close of the Ice Age and since, in the process of re-excavating such drift. After the retreat of the ice, it would appear that the valleys were partly blocked up, the rivers forming lake expansions at heights corresponding to the size of the rivers and depth of the valleys, not exceeding 200 feet along the St. John above that of the river of the present day, but correspondingly less on smaller streams. Erosion and transportation, in other words, the gradual cutting down of their channels to lower levels, would then be sufficient to account for all the observed phenomena.*

Ice-barriers.

It is to be understood, however, that the above explanation is not intended to exclude the supposed existence of ice-barriers damming up river-valleys at certain places during the glacial epoch, which alone will serve to account for the origin of a few of the terraces.

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* See report of Dr. A. R. C. Selwyn, Report of Progress 1871-72, p p. 54-56; also Dr. G. M. Dawson, in Report for 1877-78, pp. 145-194 B., for facts and inferences relating to terraces of British Columbia.

Drift-dams seem to have existed at various points along the valley of the St. John about the close of the Ice Age, maintaining the river at an elevation equal to that of the highest terraces referred to. Evidence of one having occupied the valley immediately above the mouth of the Aroostook, was observed, and others appear to have existed between that and Grand Falls, where the terraces are developed on a magnificent scale. The whole St. John valley, indeed, from Woodstock to St. Francis, has been occupied with drift obstructions at the period mentioned. Drift dams.

The former existence of lakes, or lake-like expansions of rivers, (notably along the St. John,) is evidenced, as stated above, by terraces and other phenomena, and the large lake, which is supposed to have been held in between Grand Falls and the mouth of the Madawaska by the drift-dam at the former point, prevented the erosion of the original drift beds in this part of the valley to as great an extent as elsewhere. The clay beds and intermingled materials are less oxidized, and wherever covered by sand or gravel, have generally a bluish tint. This color may be partly due to their calcareous nature, as they are largely derived from the Silurian slates of the district; but it is also probable that at the time of their original deposition they were excluded from the atmosphere, and, lying almost undisturbed since, have retained the colors they then had. The whole appearance of the deposits in question is indicative of their lacustrine character. Lake expansions along rivers.

The materials composing the beds occupying river-valleys and lake-basins were described in my report of 1882-83-84, and shown to be, generally speaking, (1), loam on top, (2), sand and gravel, and (3), clay with probably till in the bottom. One or other of these divisions, is however, often absent. On the higher grounds, where the land is dry, the surface deposits usually consist of (1), stratified sand or gravel of varied texture, with lenticular sheets of stratified clay beneath, and generally till in the bottom. In the hollows on this surface there are often thin clayey or loamy sheets, which have been deposited as the wash from the surrounding slopes. The sand, gravel and till almost always contain boulders of the underlying or subjacent rock. The thickness of these beds varies from a few inches to 10 or 20 feet or even more, but often one or the other of the series is wanting. Generally speaking, the thickness depends upon the nature of the underlying rock, whether hard or soft. The deposits overlying the Silurian and Carboniferous areas constitute a deep soil, while over the Pre-Silurian it is thin and gravelly. Character of materials in terraces and river valleys. On higher grounds.

In the lower parts of the uplands, which are often wet and form swamps ("swales," or "caribou plains"), the series is (1) a stratum of decayed vegetable, or peaty matter from a few inches to several feet in Character of materials on uplands.

thickness; (2) a hardpan beneath, composed of fine sand and clay, and almost impervious to water, usually a foot or two deep; and (3) sand and gravel with boulders, and sometimes till in the bottom, generally closely packed. As on the drier grounds, the thickness of the deposits in the swamps varies, but is usually considerable, the till being evidently much thicker there than upon the low ridges or uplands.

Remarks on origin of stratified beds.

The origin of the till, moraines, etc., was explained under a former head, and in this connexion it may be remarked, as regards the *valley-drift* and the materials occupying the higher levels, that they consist largely of sand, gravel, etc., derived from the till. In the shifting process which large portions of the rock *débris* underwent during the glacial epoch, the elevations would naturally become denuded and greater quantities deposited in the valleys. This valley-drift, when the ice began to retreat, would be arranged into moraines and kames by the smaller local glaciers which would hang about the water-sheds and elevated portions of the country, and by waters flowing therefrom; and in the river valleys and lake basins the work of erosion and remodelling into stratified beds would be carried on and the process of re-excavating the drift-filled river-channels commence. On the higher levels, many lakes and ponds would occupy the hollows, and portions of the drift would thereby be remodelled. Most of these have since become dry by drainage, evaporation, etc. Over all the higher grounds, however, there is almost invariably a stratified deposit of sand and gravel to be found resting on the till of greater or less thickness, which must have been formed from its modification by atmospheric agencies, as, for example, by thaws every spring loosening the materials and moving them down to a lower level; by rains washing down the finer materials to the hollows in which may be found the lenticular clayey patches referred to; but principally, perhaps, by the modification of the till by water resulting from the melting of the glacier or glaciers at the close of the Ice Age. Indeed the conclusion seems unavoidable, that the beds of sand and gravel referred to, with which intercalated sheets of clay occur sometimes locally, all of which are beyond the reach of fluviatile and lacustrine action, must have been produced by some sub-aerial agencies of the kind mentioned.

Probable mode of formation on higher levels.

M 2.—Leda Clay and Saxicava Sand.

Localities of Leda clay and Saxicava sand.

The deposits classed under this head, which usually contain marine fossils, are confined, so far as known, to the coastal area and river estuaries in New Brunswick. For the most part the Leda clay forms detached sheets, of greater or less breadth, and is not spread continuously over the maritime district referred to, but appears better developed at or near the mouths of rivers than elsewhere. In the Baie des Chaleurs basin, the two (Leda clay and Saxicava sand) occur

together in patches all around its southern border and up the Restigouche valley as far as the mouth of the Upsalquitch usually in regular position, that is, the sand overlying the clay. Their greatest thickness, as seen together to the west of Bathurst harbor, is Leda clay, 75 feet, Saxicava sand, 50 to 60 feet; but in the Restigouche estuary at Oak and Battery Points, the Saxicava sand alone is seen to be 150 feet thick. On the banks of the Tête-à-gauche River; the clay is found as high as 90 above sea level, while in St. Ann settlement the Saxicava, or overlying sand, reaches an elevation of 150 to 175 feet. This is the greatest height of these beds in the Baie des Chaleurs district, so far as observed. In the Bay of Fundy region they present similar features and characteristics, but penetrate the interior along the rivers farther, and are nowhere found at greater elevations above sea level than 200 feet. The total vertical thickness of the series in New Brunswick must exceed the above estimate considerably, however, as everywhere along the coast it descends beneath the sea, and some of the richest fossiliferous beds pertaining to the Leda clay are found below high-tide level, as at Charlo and Jacquet Rivers at the Baie des Chaleurs, and Sand Cove on the Bay of Fundy coast.

Greatest thickness of those deposits in northern New Brunswick.

In regard to the materials constituting these deposits, they seem to be derived partly from the denudation of the coast area by the sea, but chiefly from the detritus of the numerous rivers and brooks debouching into the bays and straits along the coast, the thickest accumulation being found at the mouths of rivers and along estuaries. And the nature of the rock or drift-beds, whence the materials were derived, seems to have been influential in determining the character of the Leda clay and Saxicava sand. For example, in the Baie des Chaleurs basin, where calcareous rocks prevail, they have furnished considerable quantities of material suitable for clay, and hence the Leda clay is well developed there, and from its calcareous nature is prolific in well preserved fossils. In the Bay of Fundy region on the other hand, there is a mixture of calcareous and other sediments, and hence it is only in certain localities that we find clay beds and fossils. Along the coast of the central Carboniferous area, the beds, being chiefly derived from the Carboniferous sandstones, are largely composed of sand, hence fossils are rarely, if at all, detected. It is thus apparent that the materials of these clays and sands are largely derived from the rock *débris* of their own immediate neighborhood. Where they overlie kame deposits, they are invariably packed with boulders from them. At the mouths of rivers running through a limestone district, blue calcareous clay prevails, while reddish clay is invariably met with in districts in which red Lower Carboniferous rocks occur. In the middle Carboniferous district the clay is generally grey in color.

Source of the materials of these deposits.

Their relation to the rocks of the country.

Leda clay not divisible with upper and lower.

No separation of the Leda clay into upper and lower divisions seems possible, but in some places the upper portion is yellow or brownish from oxidation by percolation of surface waters and other atmospheric causes. The lower portion indicates deposition in moderately deep, or quiet waters. There would seem, however, to have been a gradual shoaling during the deposition of the Leda clay, the upper part often bearing traces of having been formed in shallow seas, lagoons and estuaries, the material being coarser and boulders not uncommon. The fossils are largely confined to lenticular, muddy strata in the upper portion of the Leda clay.

Fossils.

Saxicava sand.

The Saxicava sand is wholly a shallow water deposit, and contains gravel and small boulders derived from pre-existing drift deposits, and like the Leda clay partakes of the character and even color of these. In the somewhat extensive terraces of Saxicava sand, near Bathurst, the pebbles consist chiefly of granite, felsite and slate. The materials appear to be such as were carried down bv the rivers and worn off the coast area by the sea; but, from their greater thickness at the mouths of rivers, principally from the former source.

Scarcity of fossils in it.

The Saxicava sand seldom contains fossils. Mr. G. F. Matthew states (Report of Progress, 1877–78) that *Mya arenaria* and *Macoma fusca* occur in it on the coast of the Bay of Fundy. In the Baie des Chaleurs sand, fossils were found only in one place, viz., at Benjamin River, and at about its contact with the underlying clay, the species met with being *Mytilus edulis*, var. *elegans* of Sir W. Dawson's list. The Leda clay abounds in fossils here, which are found principally in the upper strata, however, and considerable beds forming the lower portion along the Baie des Chaleurs coast are quite unfossiliferous. These latter are often impregnated with iron or other matter destructive to shells, to which cause they may partly owe their unfossiliferous condition.

Why portions of Leda clay are unfossiliferous.

The following shells were collected in 1884, from the Leda clay of the Baie des Chaleurs basin:—

LIST OF POST-TERTIARY FOSSILS, COLLECTED IN 1884, FROM THE LEDA CLAY OF THE SOUTH SIDE OF THE BAIE DES CHALEURS.*

CRUSTACEA.

1. *Balanus crenatus*, Brug. River Charlo, Beaver Point, Jacquet River, Tête-à-gauche River. Very common.
2. *Homarus Americanus*, Edw. (Claw of.) In railway cutting, near Beaver Point.

* Vide Report of Progress, 1877–78, for Report on the Superficial Geology of Southern New Brunswick, by G. F. Matthew, M. A., containing a list of Post-Tertiary fossils, a number of which belong to the Baie des Chaleurs basin.

MOLLUSCA.

Lamellibranchiata.

3. *Leda minuta*, Fabr. River Charlo, Beaver Point. Rare.
4. *L. pernula*, Muller, " " Abundant.
5. *Mya arenaria*, Linn. " " Common.
6. *M. truncata*, Linn. " " "
7. *M. truncata*, Linn., var. *Udevallensis*. River Charlo, Beaver Point. Common.
8. *Mytilus edulis*, Linn. Benjamin River.
9. *Nucula tenuis*, Montagu. River Charlo. Rather scarce.
10. *Saxicava rugosa*, Lam. River Charlo, Beaver Point. Very common. This and *Balanus crenatus* are the two most abundant species.
11. *Macoma calcarea*, Chemnitz. River Charlo, Beaver Point. Common.
12. *M. fragilis*, Fabr. = *M. Grœnlandica*, Beck. Last two localities.
13. *Yoldia arctica*, Sars = *Portlandia glacialis*, Gray = *Leda truncata*, Brown. Last two localities and Jacquet River. Rare, except at latter place.

Gasteropoda.

14. *Buccinum undatum*, Linn. River Charlo. Not common.
15. *Neptunea despecta*, Linn., var. *tornata*. River Charlo. Rare.
16. *Margarita striata*, Brod. and Sowb. " Very rare.
17. *Natica clausa*, Brod. and Sowb. " Not common.
18. *Serripes Grœnlandicus*, Chemn. River Charlo, Beaver Point. Rather abundant.
19. *Bela harpularia ?* Couthuoy. River Charlo. Scarce.
20. *Trichotropis borealis*, Brod. and Sowb. River Charlo. Scarce.*

These fossils are usually intermingled and packed together in lenticular strata in the upper portion of the clay, as already stated, so that it is impossible to separate arctic from sub-arctic or other species, and their value, as indicative of the depth of water in which they lived, is not to be greatly relied on. It appears probable, however, that the sea which they tenanted has been comparatively shallow, for not only has the upper surface of the clay been eroded and channelled by currents

Mode of occurrence of fossils.

* I am indebted to Mr. Whiteaves, Palæontologist to the Survey, for the identification of some of the species and a revision of the above list.

previous to the deposition of the Saxicava sand, but the fossils themselves, in many cases, indicate that they were washed about by currents and thrown together in masses, occurring often compacted two or three inches deep, with the valves mostly separated and broken. Occasionally, too, they seem to occupy pockets or holes in the upper part of the clay and are heaped up sometimes on one side or the other of the larger boulders. The frequent commingling of deep water and littoral species may thus be accounted for, the sea having washed those from shallower waters into greater depths and *vice versâ*.

The fossils indicative of sub-arctic climate. The assemblage of shells in the foregoing list, along with those recorded by Mr. G. F. Matthew from the same region, indicate that the climate of the Baie des Chaleurs district was probably sub-arctic in character at this stage of the Quaternary epoch, as similar species inhabit the seas on the coasts of Labrador and the south of Greenland at the present day. Nevertheless, its waters must have formed a favourite retreat for marine life, for the shells are not only abundant, but remarkably strong and well developed.

The shells of the Bay of Fundy Leda clay show some amelioration of climate there from that which obtained in the Gulf of St. Lawrence, as shown by Mr. Matthew, so that the existing geographical barriers influenced the character of the shallow-water marine fauna then as they do now. Only a few of the species found in the Leda clay of New Brunswick now inhabit the seas along its coast.*

Marine terraces. The Leda clay and Saxicava sand often form terraces, usually two or three together, examples of which may be seen near Bathurst, at Charlo River and along the Restigouche, also at the confluence of the North-West and South-West Miramichi Rivers, as well as at many places on the coast of the Bay of Fundy, described by Mr. Matthew.

Sections of marine deposits. Sections of the deposits under consideration were made at the under-mentioned localities. The series is in each case descending.

At Campbellton. 1. At Campbellton, Restigouche county, near mouth of Millstream:—

	Feet.
1. Loamy and sandy material, in places changing to gravel ..	5 to 10
2. Greyish-brown, oxidized, tough calcareous clay, holding fragments of marine shells (*Mya* and *Macoma*),........	1 to 5
3. Bluish-grey, tough calcareous clay, with fragmentary shells of *Balanus crenatus*, *Serripes Grœnlandicus* and *Macoma calcarea*. Thickness unknown, but above the river level it is..	5 to 10
	25

* See Sir J. W. Dawson on the Post-Pliocene of the St. Lawrence valley; Mr. Matthew on the Surface Geology of New Brunswick, *Can. Naturalist;* Also a paper by the writer, *Can. Naturalist*, Vol. X. No. 4.

These beds here form a terrace 15 to 25 feet above tide level in the Restigouche estuary.

2. Another section of the stratified beds was measured in the Restigouche valley, at the Intercolonial Railway bridge, near the mouth of the Metapedia, The course of the Restigouche River, at this point, is about N. 50° E. A hill 400 feet high rises on the right bank sheer from the river's margin. Course of the section N. 40° W., or about at right angles to the direction of the river. At mouth of Metapedia.

1. River, width of, following above course, 210 yards.
2. Intervale on left bank, 5 to 7 feet high; 345 paces wide. Chiefly loam with pebbles intermixed. Sandy loam on summit, and in some places pure sand.
3. Terrace, 12 to 15 feet high; 90 paces wide. Gravelly loam.
4. Terrace, 35 feet high; 50 paces wide. Gravel.
5. Terrace, 45 feet high; 10 paces wide. The same as the last, with boulders.
6. Terrace, 55 feet high; 10 paces wide. The same.

Behind these, a mound rises 175 feet high, apparently composed of till. It is irregular in outline, and occupies a position opposite a gap in the hills behind, through which a small stream flows. These hills rise 400 to 500 feet above the river.

3. Behind the Metapedia Salmon Club house, at the confluence of the Metapedia and Restigouche Rivers, an interesting series of beds occurs, which appears to be partly marine and partly fluviatile. It forms a terrace 160 paces long and 35 wide; height above the Restigouche River, at the railway bridge mentioned, 70 feet, above tide level 88 feet. The following is the succession in descending order:— Behind Metapedia Club House.

		FEET.
1. Fine, friable, yellow or brown earth	1 to	2
2. Dark grey sandy loam	3 to	4
3. Gravel, with numerous water-worn pebbles, almost wholly of calcareous slate, from one to six inches in diameter	12 to	15
4. Sandy loam, becoming clayey in bottom	5 to	8
5. Dark grey clay, in places bluish, holding marine fossils, *i.e.*, *Mya* and *Macoma*; depth unknown. In cutting	15 to	20
		49

The above measurements are only approximately correct, the face of the section being denuded.

Nos. 4 and 5 are marine, but Nos. 1, 2 and 3 are probably fluviatile, at least 1 and 2 are closely similar to loams overlying terraces along rivers in the interior, while No. 3 is perhaps the transition deposit. Deposits both fluviatile and marine.

No. 4 has an uneven surface as if it had been eroded previous to the deposition of the overlying beds. On the surface of the terrace, or beach, a transported boulder of diorite, three feet in diameter, and another of trap, one foot in diameter, were seen.

Newcastle.

4. At a brick-yard on the bank of the Miramichi River, just above Newcastle, the following section was measured.

	FEET.	INCHES.
1. Sand, with coarse layers towards the top, and lenticular stratification in some places	7	0
2. Reddish-brown clay, the same as No. 3, but oxidized	5	6
3. Dark grey, finely-stratified, arenaceous clay, with carbonaceous matter. Thickness unknown, height above tide level in river	6	6
	19	0

These deposits extend along the bank of the Miramichi opposite Beaubair's Island half a mile or more, with a width of a quarter of a mile, and appear to have been laid down in an eddy or cove while the land stood at a lower level.

Sections in Bay of Fundy region.

Mr. Matthew has given sections of the Leda clay and Saxicava sand in the Bay of Fundy, in the report cited (Report of Progress, 1877-78), from which further information can be obtained.

M 3. Alluviums, or Recent Deposits.

Fresh-water Beds.

Alluviums.

These include all the fluviatile and lacustrine deposits, such as marshes, peat bogs or caribou plains, marl-beds, river-flats (intervales), etc.

Formations around margins of lakes.

Around the margins of the lakes, small areas of marshy or peaty beds occur, formed of sediments washed down from the surrounding slopes, mingled with vegetable matter, such as remains of mosses and ericaceous plants which have grown and died *in situ*. These are increasing in breadth from the causes mentioned, but their extent is, on the whole, inconsiderable. Some lakelets are bordered with a ridge of gravel and sand resembling a kame, which appears to have been formed by the expansion or movement of the ice which gathers on their surfaces every winter against the shores. Phenomena of this kind can be seen at Lake Elsie, Kent county; Spruce Lake, St. John county, etc., also in certain places along river banks.

Intervales.

Extensive intervales, certain portions of which are called marshes, extend along the St. John and other rivers. Some of these were described in detail in my former report. Below Fredericton, more especially in Sunbury and Queen's counties, they form wide tracts,

which are overflowed every spring, and comprise some of the richest lands in the country. Similar intervales are found along all the rivers, occupying a greater or less breadth.

Peat bogs are met with in all parts of the province, and are of various sizes from a mere patch up to areas of many square miles in extent. A few of these may be enumerated, viz :— Peat bogs.

1. At Belledune, Gloucester county, one half a mile long, and 300 to 400 paces wide occurs. Underlain at the depth of 2 to 4 feet by shell marl. Height of the surface of the peat above sea level, 5 to 10 feet.
2. At River Charlo another occurs; length, 1½ to 2 miles along the coast; width ½ to 1 mile.
3. A peat bog crosses the Intercolonial railway about three miles south of Weldford station; width about a quarter of a mile; length unknown.
4. At about a mile or a mile and a half south of Canaan station, Intercolonial railway, a peat bog a quarter of a mile wide crosses it, and some distance further south, another, half a mile wide. These two are merely portions of one bog, and seem to unite a short distance east of the railway.
5. About three miles north of Berry's Mills station, another is crossed by the railway track, which is a quarter of a mile wide or less.
6. A small peat bog occurs at Kent Junction, Intercolonial railway, and several others along the Kent Northern railway. One, about two miles or more in diameter, is seen six to seven miles above Kingston village, Kent county.
7. A peat bog, a quarter of a mile wide, crosses the Intercolonial railway just north of Bartibogue Station, and four to five miles further north another was seen of about a mile in width. These two, I am informed, join to the west, and form an extensive "caribou plain."
8. Near Point Escuminac, Northumberland county, a peat bog several miles in length is met with, referred to by Mr. Ells in one of his reports. It is said to be 30 feet deep.
9. Peat occurs on Shippegan and Miscou Islands, but the deposits were not visited.
10. In the south of the province they are numerous,—a peat bog is crossed by the New Brunswick railway, about halfway between McAdam and Watt Junction, along the dead waters of the upper Digdeguash River. Hillocks of till and gravel occur here and there in it. This is also called a "caribou plain," or "cranberry barren."

Peat bogs are common in the valleys among the crystalline rocks of the southern counties, but they are usually of limited extent.

11. Peaty bogs or marshes occur along the thoroughfares between the two Magaguadavic Lakes, also between Grand and North Lakes, and along the head of Eel River, York County.
12. Behind some sand hills in Lincoln, Sunbury county, peat bogs lie. Their area is small.

13. A peat bog, a mile long, and a quarter to half a mile wide, lies on the N.E. branch of Portage Brook, an affluent of the Nepisiguit River. General direction, N.E. and S.W.; height above sea level, 800 feet. The depression occupied by it once formed a lake-basin.

14. At the head of the Keswick and Nackawicac Rivers there are peat bogs. One, five or six miles east of Millville, is half a mile or more in diameter, and shaky when walked upon.

15. In the St. John valley, in Madawaska county, where it is wide and flat, there are peat-covered areas overlying the stratified deposits. One of these, below St. Basil, forms a tamarac swamp.

16. Along the Madawaska River, five to seven miles from its mouth, "cranberry barrens" occur in the valley. The peaty matter is only a few inches deep, and is underlaid by a clayey hardpan.

17. Peat also occurs at Lawlor's Lake, St. John county, underlaid with marl, as described by Mr. Matthew.

Peat bogs on coast. In many places along the coast of the Bay of Fundy and Baie des Chaleurs, peat beds are seen to extend below sea level, showing a slight subsidence of the region since the period of their growth.*

Area and character of intervales or river flats. Intervales accompany every river in New Brunswick with greater or less breadth, and comprise thousands of acres of the very best lands. They are generally composed of sand and gravel underneath, with a covering of loam of variable thickness, and are overflowed every season. The freshets deposit a thin stratum of silt upon them, which, by yearly increments, has given them their present thickness, and there seems no reason to doubt that these intervales have been wholly formed in this way, that is, from the sediments of spring freshets. They often attain a thickness of 5 to 10 feet, and are usually unstratified; they consist of very fine sand and clayey matter which were held in suspension by the waters, till reaching a quiet place they were dropped. **Probable mode of origin.** The unstratified character may be partly owing to the fact that each layer of silt, as it became dried after the recession of the freshets, was liable to be disturbed by the rains and frosts and blown about by the winds. The roots of growing vegetation would likewise have the same effect; so that ultimately, from the incoherent nature of the materials, they would assume an unstratified, homogeneous appearance. The loam of our river valleys appears to be, therefore, of the nature of the loess of the Mississippi valley and other countries.

The whole amount of loam or river silt, described in this and the preceding report, already cited, seems thus to have accumulated by yearly or periodical increments in past ages, and in the lower intervales is still accumulating.

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* This subsidence may, however, be chiefly local, and due to a compression of the beds.

Infusorial earth occurs at Pollet River Lake, King's county, and Fitzgerald Lake, St. John's county. At the latter place there is a large deposit. Tripolite.

Marine Beds.

These deposits consist of salt marshes, sand dunes, estuarine flats, etc. The salt marshes occupy a large area on the Bay of Fundy coast, more especially in Westmoreland and Albert counties. The material composing them is largely derived from the waste of the Upper and Middle Carboniferous rocks of this part of the province, and is a reddish-brown mud, in some places varying to grey, which is well described in Dawson's *Acadian Geology*. In other localities it changes to a loam. Along the inner margin, near the drier grounds, the loam or clay is often covered with a peaty deposit, water-soaked a great part of the year. Twigs, sticks, logs and other matter are sometimes found buried up. The level of these marshes is about equal to that of the highest tides of the Bay of Fundy, and their area in Shepody Bay and Cumberland Basin, in New Brunswick, is many thousands of acres. Marshes of smaller extent occur near St. John city. Character of marine beds. Height and area.

Along the Gulf shores, salt marshes are met with in many places bordering the lagoons which are enclosed by the sand barriers interruptedly stretching from Baie Verte to the entrance of Baie des Chaleurs. They occur chiefly at the mouths of rivers, as at Richibucto, Kouchibouguac, Baie du Vin, etc.; but are, on the whole, of small extent compared with those of the Bay of Fundy. The sand dunes and beaches which enclose the lagoons referred to, skirt the shores along the Carboniferous area, but are best developed northward of the mouth of the Richibucto, and from there to Miscou Island form a series of long, low banks, or islands along the coast, chiefly of blown sand. Some of them are covered by a stunted growth of spruce and birch, and also with coarse grasses and carices. On the Baie des Chaleurs coast, these peculiar formations are absent, or rather are replaced by dunes of much coarser sand jutting out into the bay, forming what are called "points." Noteworthy examples occur at Bathurst, Belledune, Heron Island and other places. These dunes appear to have been formed by annual or periodical increments of sand and pebbles thrown up by the waves. Salt marshes. Dunes.

Estuarine flats are in process of formation at the mouths of many of the principal rivers, which are usually laid bare at ebb-tides and covered with eel-grass (*Zostera marina*), ditch-grass (*Ruppia maritima*), etc. In the upper part of the Restigouche estuary a basin five to six miles long and two to three wide exists, which is filled, chiefly with sand, up to the level of low tides. An extensive flat stretches from here to the eastern end of the estuary at Dalhousie, the material becoming finer Estuarine flats

in that direction. Clay beds are being deposited in the coves bordering it, in which shells of *Macoma fusca* are imbedded. A study of these estuarine deposits would exemplify the formation of the marine Post-Tertiary beds which occur in the vicinity.

Geological Relations of the Surface Deposits.

Relation of surface deposits to the solid rocks. The geological structure and mineralogical composition of the rocks of New Brunswick have had an important influence upon the character of the surface deposits, and more especially on their agricultural capabilities. In general, an intimate relation may be said to exist between the unconsolidated materials and the strata immediately underlying them; but there are exceptions to this rule to which I shall presently refer. In preceding pages an attempt has been made to show how these loose deposits originated, and it was inferred that they were produced by a series of causes which may be briefly stated as follows:—(1) The gradual decay or degradation of the rock surface of the country chiefly by subaerial erosion; (2) the subsequent shifting and grinding down of portions of these materials, and the abrasion of the rock-surface beneath through the agency of glaciers and icebergs; and (3) the re-arrangement of the uppermost portion of these materials by the action of water, either fluviatile, lacustrine or marine, through which they have been re-assorted and stratified into clay, sand, or gravel beds, etc.

How formed.

Soils of New Brunswick. The deposits constituting the soils and sub-soils of the province are mainly divisible into two classes—(1) those which rest upon and are almost wholly derived from the underlying or subjacent rocks: and (2) those which consist, to a considerable extent, of transported materials and have merely a partial relation to the rocks immediately beneath. The first may be found upon the surface of the great Silurian plain which extends from the Gaspé peninsula across the northern part of New Brunswick into the New England States. They also occur upon the central Carboniferous area, but in the case of the latter district it is found that those of local origin are intermingled with a certain proportion of foreign material derived chiefly from the Pre-Carboniferous band to the northwest.

Deposits covering Silurian rocks. On the Silurian area referred to, the deposits under consideration are largely made up of the *débris* of the calcareous slates which they cover and to which the soil, in a large degree, owes its fertility. These slates are traversed, however, by numerous dykes of felsite, dolerite and other eruptive rocks, the *débris* of which has been intermixed with these calcareous materials. The superficial deposits mantling this tract of country are often deep, more especially in the interior, and while in some places tolerably free from boulders, in others there is a large admixture of them derived chiefly from the intrusive rocks mentioned.

The land is high, as already stated (800 to 1,000 feet), except along the immediate coast of the Baie des Chaleurs, and having a rolling surface is generally well drained by the numerous streams which traverse it.

Deposits overlying Carboniferous area.

On the Carboniferous plain a tolerably deep and uniform covering of surface deposits is found, principally furnished from the destruction of the underlying strata. Disseminated through them, however, but chiefly scattered about over the surface, occur boulders derived from the Cambro-Silurian and Pre-Cambrian rocks to the west, and which have been transported thither by glaciers or the force of running water as stated above. The general surface of this region is low and flat, rising gently from the coast to a height of 400 to 600 feet. The rivers have cut deep trenches or channel-ways through it, and usually their banks have gently rounded, flowing outlines forming long slopes, a result of the softer nature of the rocks. On the level tracts between the river valleys, swamps and peaty barrens extend over large areas, in which the soil and sub-soil seem, so far as examined, to be composed of materials such as (1) peaty matter, (2) clay, gravel, etc., and (3) till, the whole constituting cold, barren land. From the character of the rocks which have furnished the surface deposits overlying the Carboniferous area, it will be seen that they contain little or no lime in their composition, and hence the soil is, except along the river banks, not by any means to be compared, as regards fertility, to that constituting the Silurian uplands.

Different geological relation of soils in southern New Brunswick.

In the southern part of the province, the relations between the superficial covering and the rocks beneath occur under somewhat different conditions. The geological formations there traverse the country in comparatively narrow bands, and the ice of the glacial epoch, having crossed these nearly at right angles to their strike, considerable rock *débris* has, by this means, been moved from the surface of one formation southward to that of another. To such an extent has this transportation of materials prevailed that it is only on the hills and ridges that the loose materials bear any direct relation to the rocks beneath. There has, therefore, been a greater intermingling of the materials belonging to the different geological formations of this district, those of each belt overlapping, as it were, the adjoining rocks to the south, although in a very irregular manner. It is also observed that the quantity of material derived from each rock-formation in this, as well as in other parts of the province, is directly in proportion to the yielding nature of each kind of rock to the sub-aerial and other erosive influences to which it has been subjected, and that consequently those which were more easily decomposed have furnished the largest quantities of surface materials and *vice versâ*. The Carboniferous sandstones and shales, as well as the slates of the Silurian series, have suffered

greater denudation than the Pre-Cambrian and eruptive rocks. Unfortunately, a large part of the country on the northwestern side of the Bay of Fundy, is covered by hills and ridges composed of the latter, and the surface is, therefore, hilly and broken, and, except in the valleys, it is usually strewn with boulders.

Agricultural Character, Forests, etc.

Soils and flora.

The general features and agricultural character of western New Brunswick were given in some detail in the report already referred to (Report of Progress, 1882-83-84, GG.), and I shall now proceed to describe the soils and flora of the remaining portions, treating the former according to their geological relations. Reference will also be made to the natural fertilizers, such as lime, gypsum, marl, etc., wherever they occur in workable quantities.

Northern New Brunswick.

In that large tract referred to in the north of the province occupied by Silurian strata, which includes Restigouche and Madawaska counties and portions of Victoria, Carleton and Gloucester, the surface is undulating and the soil, as already remarked, deep, with clayey beds in places, but is more usually a gravel, carrying greater or less quantities of pebbles; and being largely derived from the limestones and slates beneath, is highly calcareous, so much so, indeed, that only on the alluvial flats and peaty swamps would lime as a fertilizer be of any benefit to it. Intervales and terraces of greater or less width, affording excellent soil, skirt all the larger rivers traversing it. The whole area is well watered by rivers and streams, and well drained. Limestone is abundant, and kilns at Petite Roche, Elm Tree River, Belledune and other places, supply the local demand for lime, very little of which is used, however, as a fertilizer. The best lands in this district are in the interior, especially along the upper Restigouche and St. John waters, including the western part of Restigouche, Madawaska, Victoria and Carleton counties. The tract bordering the lower Restigouche and Baie des Chaleurs is dry and stony, from the presence of the *débris* of trap rock intermingled. (See Mr. Ells' report and maps, Report of Progress, 1879–80).

Natural fertilizers.

The natural fertilizers found in this section are lime, marl, and gypsum, the latter occurring, however, only along the southern border on the Tobique River, in Lower Carboniferous shales.

Forest trees.

The chief forest trees on the more elevated and drier grounds in this tract of country, are white spruce, balsam fir, white and red pine, white, black and yellow birch, poplar, beech, two or three species of maple, white cedar, American mountain ash, American hop hornbeam, two varieties of the shad bush (*Amelanchier*), two species of with-rod (*Viburnum*), yew (*Taxus*), etc.; on the swampy grounds we find spruce

(*Picea alba* and *P. nigra*), fir, white birch, poplar, white cedar in abundance, ash, alder, willow, red osier dogwood, sweet gale, etc., while on the intervales, along the streams, elm and balsam poplar are very common. Around the margins of clearings and on waste grounds, two or three species of cherry (*Prunus*), elder (*Sambucus*), hazel-nut (*Corylus*), sumach, etc., are met with. The growth of trees is generally large and the woods dense, and "hardwood ridges" consisting principally of birch, maple and beech, with a few spruces and firs intermixed, are prominent features of these forests. Groves, consisting chiefls of the sugar or rock maple (*Acer saccharinum*), are frequent, not only within the limits of the Silurian uplands, but in almost every other part of the province, and considerable quantities of sugar and syrup are manufactured from the sap which is obtained from these trees by tapping them every spring, in March and April. Heath plants are not by any means so abundant as in other districts in the province, the area of peaty grounds being less. The almost total absence of hemlock (*Tsuga Canadensis*) and the scarcity of black spruce (*Picea nigra*), and several shrubs common elsewhere, —among them the sweet fern (*Myrica asplenifolia*)—is remarkable.

Agricultural character of central crystalline tract.

Skirting the Silurian area, just described, on the south, and lying between it and the Carboniferous series, is the belt of ancient rocks already mentioned, which is, for the most part, covered by forest. These rocks extend across the country from the Baie des Chaleurs to the Maine boundary, and from their structure and more crystalline character from a more elevated tract than the series on either side, more especially in the central part of the province. Having been crossed nearly at right angles by glacier-ice, they have furnished large quantities of their *débris* to the soils overlying them as well as to the district immediately to the south east. Much of the area they occupy is hopelessly barren, being rugged and strewn with blocks of all sizes in great profusion. This remark applies, more particularly, to those portions underlaid with granitic, felsitic and other eruptive rocks; but there are other tracts occupied by Cambro-Silurian slates, covered by soil, which, although hitherto considered, to a large extent, valueless from an agricultural point of view, are found actually to comprise some of the best farming land in the province. Reference has been made to settlements situated upon land of this kind in York county in my former report, and it may here be stated that other settlements have likewise been formed upon it, such as Dunlop, Dumfries, Tête-à-gauche, etc., near the Baie des Chaleurs, in Gloucester county. Mr. Ells also mentions the occurrence of belts of good land overlying the Cambro-Silurian rocks, on the Renous, Sevogle and other branches of the Miramichi River. The region traversed by these belts

is generally flat and the soil usually stony and liable from its clayey nature to be wet in rainy seasons; nevertheless, certain tracts, when once cleared and brought under cultivation, form perhaps the strongest and best soil in the country for hay and cereals. It is possible, situated as some of these tracts are near the southwestern limit of the great Silurian plain just described, that portions of the calcareous material from the latter may have been transported thither in the Ice Age, to which, in some degree, they may owe their fertility.

Trees on crystalline belt.

Respecting the forests on the area described, it may be remarked that a difference is at once apparent to a botanical eye when they are compared with those of the Silurian area. Hemlock spruce, black spruce, white and red pine, and other trees, which are rare or altogether absent on the latter, in some localities, are here common forms. Hardwood ridges are less frequent and great stretches of the interior hilly country are barren and almost denuded of forests by fires. Heath plants are more abundant in the valley bottoms and in bogs among the hills.

Soil on Lower Carboniferous.

The narrow band of Lower Carboniferous sediments, which borders the main triangular-shaped area of the Middle Carboniferous formation, crumbles down into a rich, friable soil, containing, usually, considerable quantities of calcareous matter. A wide area of these reddish beds occurs in the Tobique valley, and a smaller one on the Beccaguimic. In some places the belts are so narrow that they are wholly overlapped by *débris* from contiguous rocks; but, in general, the presence of materials derived from them is easily recognised, owing to their reddish color and their effect upon the fertility of the district. The agricultural capabilities of the Tobique outlier have been much extolled by Gesner, Hind and others. During an exploration of that river, in the summer of 1884, it was noticed, however, that many farms in the district, after having been partly cleared and buildings erected thereon, were subsequently abandoned. The cause of this was not ascertained, but it cannot be denied that, while the region is of a highly fertile character, its remoteness and inaccessibility militate against its successful settlement. Portions, however, are flat and imperfectly drained, the resutt of the existence of a clayey hard-pan forming the sub-soil. Only where the land has sufficient slope to drain it well, are really good farms available, and in localities characterized by a surface of this kind there are some thriving settlements.

The bands of these rocks, stretching along the southwestern rim of the middle Carboniferous basin in York, Sunbury, Kings and Albert counties, comprise tracts of excellent farming lands, which have been described in previous reports.

The mineral fertilizers occurring in them are gypsum, at the Plaster

Cliffs, Victoria county, and at Petitcodiac, Westmoreland county, Hillsboro', Albert County, etc.; also lime and marly shales in the last mentioned localities.

A luxuriant growth of wood is generally found upon soil derived from these rocks. White and black spruce, hemlock, white, yellow and black birches, two or three species of maple, which, with beech, usually form groves, are the commonest trees on the uplands, and cedar, hacmatac, ash, etc., on the low grounds. Forest growth on Lower Carboniferous.

The soils which overlie the Middle Carboniferous series are almost wholly derived from the disintegration of the grey sandstones and conglomerates below, and partake in a large degree of their coarse silicious nature. The area occupied by them, which comprises fully one-third of the province, is, generally speaking, flat, with a gentle slope towards the Gulf of St. Lawrence. Low, wide undulations, having a general east and west course, are met with over a large part of the area, but more especially south of the Miramichi River. The soil is, for the most part, deep, but often stony; and when level, usually has a clayey hard-pan forming the sub-soil upon which water lies, giving rise to peat bogs, "caribou plains," or "barrens." The best lands for agricultural purposes are those met with along the banks of rivers already described, where the natural drainage is sufficient to carry off the surplus waters due to precipitation. With a copious supply of lime, in which the soil overlying these rocks is almost entirely deficient, together with organic manures, it becomes excellent land for hay and grain. Several tracts might be particularized, such as Nappan valley and Doaktown, in Northumberland county; St. Louis, Richibucto and Buctouche, in Kent; the Petitcodiac valley in Westmoreland, etc. Soils overlying Middle Carboniferous series.

The farms along the coast and around the estuaries in this district are, all things considered, much better adapted for general agricultural purposes than those of the interior, as manures and fertilizers of different kinds are to be obtained there, which are beyond the reach of farmers occupying the latter. Oyster beds, forming what is called "mussel mud," are common everywhere in the lagoons and creeks, and yield a material of highly enriching qualities for the heavier clay soils. The calcareous skeletons of fish are often applied to the land also with great advantage. Much benefit is afforded the drier gravelly soils, too, by supplying them with quantities of vegetable matter from the wet bogs and swamps, more especially if it is first formed into a compost by mixture with barn-yard manure. "Mussel mud."

But the principal cause of the superior quality of the land along the coast and river margins, within the Carboniferous district, lies in the fact that it is better drained than that of the interior overlying the same formation. And here, it may be remarked that the Drainage.

general question of the drainage of the land in New Brunswick is an important one, and next to the quality of the soil is worthy of the highest consideration by the practical agriculturist. In a country such as this, where the precipitation is so much in excess of evaporation and absorption for the greater part of the year, unless some means of escape is provided for the surplus waters, either naturally or artificially, more especially for those arising from thaws every spring, they lie upon the flat clayey surfaces till late, not only retarding farming operations, but keeping the ground cold and materially hindering the growth of vegetation. If the spring and summer continue wet, crops on the low lands are thus rendered almost worthless and cannot mature properly, and the character of the land and the climate are often condemned when in reality the defects are largely owing to imperfect drainage.

Selection of farms.

The chief considerations, therefore, in selecting land on which to carry on agricultural pursuits most successfully in this province are (1) the quality of the soil, by which is meant its physical characteristics, whether clayey, sandy, loamy, etc.; (2) its height above sea level, aspect, etc.; and (3) its drainage. Unless land is well drained by streams or rivers, although the component materials of the soil may indicate a high fertility, yet it will be found unprofitable. One of the physical conditions rendering the soils overlying the Lower Carboniferous and Silurian rocks so much more valuable, agriculturally, is, no doubt, the excellent drainage resulting from their rolling surface.

Flora of Middle Carboniferous areas.

The flora of the Middle Carboniferous area, including the sylva, presents some features different from those of other parts of the country, especially of the Silurian tracts, as already mentioned. The trees are characterized by the prevalence of hemlock spruce, scrub pine (*Pinus Banksiana*), white birch and poplar; and on the flat, swampy grounds, by hacmatac (larch), cedar, scrubby black spruce and dense masses of ericaceous plants. The peat bogs are often without any but herbaceous forms, and are, no doubt, shallow lake-basins filled with decayed vegetable matter, chiefly mosses, and bordered by stunted spruce and hacmatac trees. In some of the bogs, dead trunks of the trees referred to occur standing amidst the wet sphagnous mass, showing that some change in the condition of the bog, or in the climate, has taken place since they began to grow, unfavorable to their existence. The change may have been very slight, perhaps caused by the increased growth of sphagni around their roots, or to a difference in the drainage, as their existence, which at best is but a precarious one, would be easily terminated.

Soils of Permo-Carboniferous rocks.

The eastern part of Westmoreland county is underlaid to a considerable extent by Upper or Permo-Carboniferous sediments,—rocks similar to those of the chief part of Prince Edward Island,—which fur-

nish perhaps, all things considered, the most friable, easily cultivated and productive of the soils of the Maritime Provinces of Canada. The land in the vicinity of Sackville, and the slopes of the ridges between that and the Nova Scotia boundary, also the peninsula of Cape Tormentine, and the coast region thence westwardly as far as Cape Bald, are covered by a soil largely derived from these rocks, and comprise many excellent and highly cultivated farms. Contiguous to these are the extensive salt marshes of Tantramar and Missiquash, already alluded to, a large portion of which is dyked. Dyked marshes.

The tract of country lying between the central Carboniferous area and the Bay of Fundy, extending from Albert county on the east, to the St. Croix River on the west, and including the southern part of Albert, a part of Kings, Queens, and the whole of St. John and Charlotte counties, is underlaid by rocks of different geological ages, nearly all of which are remarkable for their highly altered and crystalline character, and forming in general a rugged, broken and boulder-strewn surface. The chief topographical features and agricultural capabilities of this section were described in some detail in previous reports (Report of Progress, 1870–71, also for 1877–78), by Prof. Bailey and Mr. Matthew, and it was seen that while the valleys are generally fertile, the summits of the hills are often bare, and the slopes usually strewn with stones, nevertheless, when once cleared and brought under cultivation, the soil is often productive. The valleys, which are sometimes of considerable width, have generally a rich loamy soil, and near the coast, the creeks and inlets contain salt marshes, which, when reclaimed, are similar to the dyked marshes of Westmoreland and Albert. Soils of district along Bay of Fundy.

The surface of Charlotte county is almost similar to that of St. John and the western part of Kings as regards its soil and agricultural character. Large portions of it are boulder-strewn, and among the hills are peat bogs and barrens, rendering considerable tracts almost worthless for agricultural purposes. Overlying the Cambro-Silurian band there is some good soil when it is once cleared of boulders.

The northern margin of the area now described, which is overlapped to a greater or less distance by *débris* from the Lower Carboniferous sandstones, comprises the best land in it. In Kings county there are some excellent farms along the Kennebeckasis, particularly at Sussex Vale, which is sometimes called the "garden" of this county. It is a wide, flat-bottomed valley, which at one time must have contained a lake, the land being chiefly alluvium. The rivers in these counties are usually skirted with a greater or less breadth of intervale, and the country is extensively settled, notwithstanding the sterile character of much of the soil, by a thrifty, enterprising population, and agriculture is now receiving more attention than formerly. Soil of Kings county.

Natural fertilizers in southern counties.

The natural fertilizers are lime, manufactured near St. John, in several places, from Laurentian limestone, and marl, found in some of the shallow lake-bottoms, notably at Lawlor's Lake.

Flora.

The flora presents no marked contrast to that of the interior portions of the province, except that a few arctic or sub-arctic forms seem to find a more congenial habitat there than in the interior, owing, no doubt, to the chilling influence of the arctic current which here runs along the coast, and to the fogs which prevail in the Bay of Fundy, causing a lower summer temperature. This area is now almost wholly denuded of its timber, and the forests everywhere are but thin and straggling.

Materials of Economic Importance Found in the Surface Deposits.

Bog iron ore.

Bog iron ore (limonite) is of frequent occurrence in the alluviums overlying the Carboniferous rocks, more especially in the vicinity of the St. John River, the beds sometimes attaining a thickness of two to three feet.

Wad.

Wad, or bog manganese, is found at Queensbury, York county, and in one or two places in Sunbury county. It likewise occurs on the north branch of the South-West Miramichi, 12½ miles above the forks, in the river's bank.

Tripolite.

Infusorial earth (tripolite) is found at Fitzgerald Lake, St. John county. The Lake has been drained dry by the St. John Water Company, exposing a considerable bed of earthy tripolite. It also occurs at Pollet River Lake, Mechanics' Settlement, King's county. (See analysis by Mr. Hoffmann, Report of Progress, 1878-79, p. 5 H.)

Marl.

Marl is met with at Lawlor's Lake, St. John county; also at Belledune and River Charlo in the Baie des Chaleurs district. (Report of Progress, 1879-80, p. 42 D.) Its occurrence may be looked for in shallow lakes in limestone districts in other parts of the province.

Brick clay.

Brick clay occurs in a number of places both in marine and freshwater beds. Leda clay is manufactured into brick at Campbellton, Restigouche, Bathurst, Newcastle, Moncton and St. John, while clay, apparently of fluviatile origin, is wrought for similar purposes at Fredericton, Woodstock, Shiktehawk and elsewhere on the St. John River.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA
ALFRED R. C. SELWYN, LL.D., F.R.S., F.G.S., DIRECTOR.

OBSERVATIONS

ON

MINING LAWS AND MINING

IN CANADA.

WITH SUGGESTION FOR THE BETTER DEVELOPMENT OF THE MINERAL RESOURCES OF THE DOMINION.

BY

EUGÈNE COSTE, M.E.

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TO ALFRED R. C. SELWYN, ESQ., LL.D., F.R.S., F.G.S.
Director of the Geological Survey of Canada.

SIR,—The following observations on Mining Laws and Mining development, in Canada, are submitted in the interest of our national mining industry.

I have the honor to be,

Sir,

Your obedient servant,

E. COSTE, M. E.

March 24, 1885.

OBSERVATIONS

ON

MINING LAWS AND MINING IN CANADA,*

WITH SUGGESTIONS FOR THE BETTER DEVELOPMENT OF THE MINERAL RESOURCES OF THE DOMINION,

BY

E. COSTE, M.E.

While engaged during the last two seasons, on behalf of the Geological Survey of Canada, in the examination of several mining districts in different parts of the Dominion, I have been impressed by the unsatisfactory state of the mining industry in these districts, the unbusiness like way in which the work is carried on at most of the few mines that are being developed, the consequent immense loss to the country, and the apparent want of laws and regulations for the encouragement of real mining and the development of our great mineral wealth. Unsatisfactory state of the mining industry.

As these things forced themselves upon my attention day after day in the course of my inspection, the following questions suggested themselves: Why so little mining activity in this country so rich in mineral resources, and in which so many mining regions have long since been discovered? Why so few real mines and so meagre a production of ore? Why have so many mining schemes failed, and why, in several parts of Canada, have good mines been abandoned, which will eventually be worked again with profit? How explain that several mining districts, where splendid discoveries were made years ago, are yet comparatively unexplored, and that the true value of these districts is still unknown?

In trying to answer these questions, which concern one of the great sources of wealth for our young Dominion, I am led to the following conclusions: If our ore production is so meagre and if we have so few real mines, it is because, in the provinces of Ontario and Quebec and in the North-west, territory where the districts which I visited are Sale of "Mineral Lands."

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* These observations apply to every Province of Canada, though hereinafter the Provinces of Ontario and Quebec and the North-West Territory only, are specially mentioned.

situated, the laws allow speculators to purchase very cheaply large tracts of "mineral lands" which they are not compelled to work and which they hold, against the interest of the mining industry and of the country, awaiting fabulous prices for them and so preventing *bona fide* working companies from developing them. This is evidently the reason why so many mining schemes have failed: they were only schemes of speculators trying to make a show, and with that object in view, instead of first opening the ground to ascertain its value, as a really good practical miner would have done, they have built handsome residences and villages in the woods and have done no mining for fear the indications would "play out." It is also the reason why many companies having bought, at very high figures, from these speculators, entirely unprospected mining locations, are deceived as to the value of the property, or, in case the property happens to be good, are nevertheless too poor to work it profitably after so great an outlay of capital to purchase it from the speculators. It is because these owners of "mineral lands" put extravagant values on them, and are, in consequence afraid of the truth and fear the results of complete investigations, that our mining districts remain unprospected, on the surface as well as underground, and that we cannot arrive at a knowledge of their real value.

Scope of remarks. I shall confine my remarks to the Dominion lands and the Provinces of Ontario and Quebec, where the mining districts I have visited are situated, and shall first endeavour to demonstrate how fatal to the mining industry is the system in force under existing laws and how necessary it is to abandon the custom of selling mining properties or the mining rights if the speedy development of the already known as well as the yet unknown mineral resources of the Dominion is desired. I shall further endeavour to indicate the principles which should be borne in mind in framing laws and regulations for the disposal of mineral deposits and the encouragement of mining in new countries.

A *résumé* of the laws now in force, over the Dominion lands and in the provinces of Ontario and Quebec, or at least of as much of these as concern the acquisition of the mining rights is here indispensable.

Dominion Lands.

The following are the mining regulations which govern the disposal of "mineral lands" other than coal lands:

—Any person may explore vacant Dominion lands, either by surface or subterranean prospecting.

—A mining location, except for iron, shall not exceed 40 acres, the

length not being more than three times the breadth; the boundaries beneath the surface being the vertical planes in which its surface boundaries lie.

—For the mining of iron, the Minister of the Interior may grant a location of 160 acres. Iron.

—Having marked the location, the occupant, on paying $5 in registering the claim, shall have the mineral right for one year.

—During that year, at any time, he can purchase at the rate of $5 per acre, cash, if he proves he has expended $500 in actual mining operations on the claim, and if he makes a $50 deposit, with the agent of the Government, for the survey of the claim.

—For "placer" mining (gold alluvial digging) every person, holding a receipt renewable every year, can take up only one claim of about 100 feet square in the same locality, and this claim must not remain unworked more than 72 hours at a time.

—A royalty of 2½ per cent is reserved to the crown on the sales of the products of all mines.

As regards coal mining lands:

—They are periodically offered for sale by tender or public auction Coal.
—the lands within the "Cascade coal district" at an upset price of $20 per acre cash, and the lands within all the other coal districts at an upset price of $10 per acre, cash.

—Not more than 320 acres shall be sold to one applicant.

—Competition is invited when there is more than one applicant for the same location.

The regulations do not refer to the mining rights under lands already appropriated, or under lands which may be sold in the future not as "mineral lands," but under which mines may at any time be discovered, the mining right in these cases it is to be presumed belongs to the owner of the soil.

ONTARIO.

In the Province of Ontario we have the "General Mining Act" (Rev. Stat. 1877, ch. 29), of which the following is a *résumé*.

—Any person may explore on any crown lands not occupied.

—Crown lands supposed to contain mines or minerals may be sold as mining locations, or may, when situated within any mining division, be occupied and worked as "mining claims" under "miner's licences."

—The dimensions of the mining locations are 320, 160 or 80 acres. The price to purchase them is $1.00 an acre in the territory north or north-west of the river Mattawa, lake Nipissing and the French River.

The price for the other parts of the province is not stated in the Mining Act but is, I am informed, practically the same.

—The "mining claims" have an area of about one acre.

—Any person possessing a "miner's licence," renewable annually for a fee of $5, can occupy and mine one claim only at a time, on condition that it is worked within three months after the registration, and thereafter does not remain more than 15 days unworked.

—The discoverer of any new mine shall be entitled to two mining claims.

Quebec.

In the Province of Quebec the mining rights are dealt with in the "Quebec general Mining Act of 1880" amended in 1881, 1882 and 1884.

The following is a *résumé* of the parts of this act relating to the acquisition of mining properties or mineral rights:

—A licence renewable annually (fee $2) is necessary to prospect on the vacant lands of the province.

—The mining rights under all the lands of the province belong to the crown, even for the lands appropriated before the passing of the act, except when the "lettres patentes" give in full the mining right.

—The mining locations are 400 acres or less, but the Lieutenant-Governor in council may increase the limit to 800 acres.

—The prices are, surface and mining rights inclusive, $1 per acre for all minerals except gold, silver and phosphate (apatite), and for these $2 per acre.

—Every person working a gold or silver mining location must take a licence costing $2 every three months (even if he has bought that mining location).

—The owner of the surface, who desires to purchase the right of working a mine under his land, must pay per acre the difference between the rate he has already paid and the rate fixed for mineral lands and as stated above.

—In case of gold and silver the "lettres patentes" will only be given after the sum of $200 has been expended in working the mine; two years are allowed to do this; but, after that time, if the $200 are not expended the location may be deemed forfeited.

—The Lieutenant-Governor in council may claim a royalty of 2½ per cent on all gold and silver obtained and of 50 cts. per ton for phosphate.

Licences for gold and silver mining.

—The right to mine, for gold and silver, can also be acquired by licences allowing every person to take up one claim only at a time. These licences are of three kinds, *viz*:—

1. To work under appropriated lands: cost $1 per month per miner.

2. To work under public lands: cost $2 per month per miner.

3. To work under mining locations, granted and not being worked, or not granted: cost $2 per three months.

—The dimensions of these "claims" are: for alluvial mines about 100 feet square, and for quartz mining about one acre. They must be worked within four weeks after registration and must not thereafter remain unworked for more than 15 days at a time.

—A discoverer has a right to a free licence in force for twelve months and to a claim of the largest size.

Underground rights and surface rights.

The amendments of last year (1884, ch. 22) have recognized the principle of underground rights being entirely separated from the surface rights. They state that underground right may be bought or leased or that they may be acquired by a licence, (the owner of the surface having the first right to acquire); but, the price, the shape and the dimensions of these underground mining locations are not stated. These are to be decided by the Lieutenant-Governor in council.

Results of the existing laws.

In considering with attention these *résumés*, it will readily be seen that these laws give the three following results: I. A surface owner possesses or can buy first the mineral rights and is not compelled to work the mine. II. Very large tracts of "mineral lands" can be bought from the Crown lands without any obligations to develop these "mineral lands." In Quebec, however, when these lands are unworked, the Government may grant small claims over them, in the case of gold and silver, but without forfeiting for that the "deeds" of the owner. III. Rights to mine under small claims can also be acquired in certain cases by a licence.

Small claims.

The few following remarks may be offered in reference to the system of granting these small claims: it only retards the acquisition of many mines by good companies; it is the cause of a number of disputes on the question of possession of property; and, in some cases, it might cause also the entire spoiling of a good mine. These claims are very much too small and the working of the mines in these cases, being on too small a scale, is never satisfactory. There is nothing really practical in this: and it is only as applied to placer mines that it is good and useful, as this is the only case in which an individual miner can work a mine and make it pay.

Giving mining rights to surface owners and selling "Mineral lands."

I & II. But, it is desired especially, in this report to direct attention to the two first results indicated above of our existing mining laws. The backwardness of our mining industry has been a natural sequence of the recognition by the laws of these systems of giving mining rights to surface owners and of selling "mineral lands;" that alone impedes

and even prevents entirely in certain districts the development of the mineral resources; and, until the mining laws are changed and another and entirely different system adopted for the acquisition of mineral deposits, we shall have, as we have to day, but few mines working.

Prospecting is discouraged.

First, indeed, prospecting is discouraged. It is evident enough that the buying up of large tracts of "mineral lands" brings that result, because prospectors are not to be found who will search on granted lands in a vast new country like ours. Surface owners, having mining rights or having first right to acquire, also discourage prospecting, because then, when a mine is found under granted lands, it does not belong to the explorer, to the man who has discovered it, but to a settler who has been working his soil for a long time perhaps, without having ever had any knowledge of the existence of this mine, or to a speculator who, as a rule, has never put his foot on the land. Nevertheless, what right, in justice, have these people to this new property which they did nothing to find and which an explorer brings to light by his exertions after long, patient and very often in this country, tedious researches? Suppose it is for instance a vein 2,000 feet long with an average width of about 3 feet 4 inches, dipping at a regular angle of 45°, and that the specific gravity of the ore averages 3.5. In these conditions, a simple calculation shows that the vein, being worked to the depth of 1,000 feet and under 23 acres of the surface (2,000 feet on the length of the vein, by a width of 1,000 feet on the side of the dip), will give about 1,000,000 tons of ore. If then a profit of say $1 per ton can be made on the ore coming from that mine, it is seen that the profit to be made or the real value of the portion of the mine above the depth of 1,000 feet is $1,000,000. Such is the fortune an explorer has discoverd, that he alone indicates and creates, you may say, after perhaps many months or years of arduous tramping. Surely he ought to have some right to a portion at least of that fortune; and yet, the surface owner deprives him of it.

Rights of surface owners.

But, if by natural right and law, this property should not belong to the surface owner, it much more ought not to belong to him for political and economic reasons, and for the same reasons, the selling of "mineral lands" ought not to be authorized by our laws. Because, if it tends to lessen the number of discoveries, it also, as second result, prevents the development of the mines once discovered.

Political and economic reasons.

A vein, indeed, being discovered on the surface, one must make sure that it keeps going down, that it does not narrow until it becomes unworkable, as is often the case, that the percentage of good ore remains large enough in the vein, that the difficulties of working, due to water or other causes, will not be too great, etc., etc. All this must be known before it can be said that a good mine exists, and to ascertain

this, the vein must be explored underground by shafts and levels. This is expensive work, much more so than is generally known, and it may cost many thousands of dollars, always several thousands. It is also a very difficult work, often exceedingly so, and even the best scientific and trained mining engineers sometimes make mistakes, and every mistake costs a great deal of money. Is not then an incompetent man almost certain to make a failure of it? Who is going to do that work of testing the ground? Evidently not the settler, for if he has the misfortune to try it, he will spend every year more money on small excavations sunk in all directions, than the cultivation of his land can yield him, and he never will know how to do the work, and at what results he has arrived, if he arrives at any. The district of North Hastings (Ontario) is pierced everywhere by small excavations such as I have mentioned, sunk by settlers under their lots. I have visited many of these excavations and in most of them I failed to find a trace of ore, though they represent a large amount of time and money lost, and, many farmers neglect their farms on that account. If the farmer tries to have the work done for him, it will always be on too small scale and is in consequence doomed to failure. He will probably give the work to a so called "old miner" just arrived frnm California, Australia or Cornwall. This man knows it all; he will tell the farmer every night that he has done excellent work during the day, that no doubt it is a wonderful mine, that he sees an immense treasure ahead of him in the level or in the shaft, that, true, the expense has been great and nothing has yet been found, but wait, next day he will strike the lead and show him the treasure; and this goes on from day to day until the poor settler is compelled to give it up. And yet, he still believes in his wonderful mine!

Testing the ground.

It is with the same result generally that the speculator tries to work his lot, his object being only to develop it sufficiently to affect a sale.

Mining engineers and mining men supported by capitalists alone are able to take up these works of newly discovered veins underground exploring. They alone can develop that fortune discovered by the explorer. Why then are these new discoveries allowed to be or to become the property of persons who acquire them either by accident or only for speculative purposes?

Mining men alone are able to do it.

If mining is a difficult matter requiring specially trained men; if it is an expensive work requiring a great deal of capital; it is also, so long as a thorough underground prospecting has not been made, a very uncertain business to go into especially in a new country where there is no comparison with neighbouring mines to be made. Mining men know that, they know that a good vein may pass at any moment to a bad one, and in consequence they will never pay, on the evidence

Hindered by exhorbitant demands of owners.

merely of the outcrop of a vein, the enormous sums of money asked by the owners of soil. They are willing to run the chances if they have not to pay too high a price for the property; but under the present conditions, they will not try it. They will leave mining districts disheartened, not that they find the district worth nothing, on the contrary, they see there brilliant prospects, but what can they do? They find all the properties bought, all the mining rights acquired and everybody asking them enormous sums, cash, before being allowed even to explore the mine by shafts and levels. And yet this district is very little worked, and though good and discovered many years ago, nothing is to be seen there except shafts full of water and abandoned excavations, remains of the meagre efforts made by the owners of the soil and the speculators to develop their deposits just enough to make a show in order to sell the property.

Necessity of permanent leases which should be terminated only by non-fulfilment of conditions.

I may say then, in conclusion, that it is quite necessary in the interests of our country, in the interest of our mining industry which once developed will perhaps give us the millions that our neighbours of the United States have taken out of their mines and on which is based much of their prosperity, that the mining properties should be held as national property regulated by good laws and leased permanently and directly to *bona fide* mining men, on conditions including forfeiture when sufficient work on them is not being annually done.

Why not, indeed, prevent a farmer or a speculator from imposing a heavy charge on a mining company willing to run the risks of exploring and working a mine? Why, for what purpose, should the laws place between the government and the real miner, this surface owner, who, with his often primitive and exagerated ideas of mines, does not consider the enormous expenses and the uncertainty attending the work of underground mineral exploration nor the large capital required for the subsequent regular working of a mine, and will always add to that a formidable demand for money before even allowing explorations to be made on his property; this property having been bought from the Government at $1.00 an acre and on which he did nothing himself to discover the mine? I say a formidable sum, because I know of many instances where twenty, thirty and even one hundred thousand dollars have been refused by such owners of the surface.

The Canadian government protects many industries, often bonuses are given, the development of our agricultural resources is encouraged: why not also protect our mining industry? To day, before sale, surface rights and mining rights are the property of the country, and the country, in the interest of our mining industry, instead of giving away these rights for a few dollars an acre, should carefully guard the mining right by good legislation, because good mines are rare golden

eggs which a nation must protect with great care. A large country like ours, indeed, has so many millions of acres of good lands that land speculation, though very prejudicial, can be overlooked; but, as regards mining, it is very different. Such a thing as "mineral lands" extending over large tracts of country does not really exist; and nature has been more parsimonious with mineral deposits than speculators suppose when they buy thousands of acres in a district thinking they have a mine under every lot. No! good mines, even in a very large country, are always scarce, for geological reasons (mineral deposits geologically being only accidents), for technical reasons (many deposits not being valuable because of the great difficulties of mining them or of treating the ore), for economic reasons (mineral substances being often found too far from market, or from a railway, or being in too small quantity), etc.; then, once a good mine is discovered, its permanent working by a good company should be encouraged and assured. To attain this end, the country must keep the mineral rights in its hands so as to be free, when a mineral deposit is found anywhere, to give the right to mine it to a good company, and if this right is given without charge of any sort before profit is made, it will assure those going to work every possible chance of success and it will encourage capitalists to try and develop every place where the surface indications are good, because the only money to risk will be the necessary money to test the ground. It is but just, however, that the laws should oblige these capitalists, from the day they make a profit, to suitably renumerate the original discoverer. In that way, instead of having thousands and thousands of acres of so called "mineral lands" bought * and lying for years and years unprospected, unworked and in no way profitable to anybody, we shall see on the contrary, here and there, some mines actively worked expending vast amounts in the country, bringing workmen in, creating around them villages and towns; and every one of these mines will be more benefit to the Government and to the country than thousands of granted mining locations undeveloped and not only totally useless from a mining point of view, but doing much damage to the other interests of the country and often to the speculators themselves.

No large continuous tracts of "Mineral lands."

Scarcity of good mines.

The permanent working of a good mine should be assured.

Great value of good mines.

As will be seen from the following suggestions which I venture to make in conclusion, nothing could be easier than to change entirely the old system of selling "mining lands" and to attain the results just stated. The national mining property would then be submitted, in its general

Suggestions to change the system of selling "Mining lands."

* See "Plan of part of the North shore of Lake Superior showing Thunder and Black bays, etc.," published Toronto, 1st August, 1883, (department of Crown Lands), and showing how much "mineral lands" is taken up in that regioh.

outlines, to the same kind of administration that has been adopted: in France by the mining law of the 21st April, 1810; in Austria by that of the 23d may, 1854; in Italy, except in the southern provinces, by the royal warrant of 29th November, 1859; in Prussia by the general mining law of 24th June, 1865; in Bavaria by the law of 20th March, 1869: in Spain by the laws of 6th July 1859 and 13th July 1867; in Turkey by the regulations of 3rd April, 1869; and in Greece by the laws of 1861, 1867 and 1877.

PRINCIPLES WHICH SHOULD BE FOLLOWED IN DETERMINING THE CONDITIONS UNDER WHICH MINING RIGHTS SHOULD BE ACQUIRED AND MAINTAINED.

Explorations encouraged by giving rights to the discoverer.

1. Encouragement of explorations:

By recognizing and giving a right to the explorer on the mineral deposit that he discovers. This right should be in proportion to the value of that mineral deposit and consist in consequence in a certain annual royalty on the profits made out of the mine (say 5 per cent of these profits). This rent or royalty will be due every year in which profits are made by the lessee and until the death of the discover.

By further giving to the discoverer, if he wish, time to organize a company himself to lease and work the mine—say six months or nine months after the registration of his discovery.

Prevention of speculation.

2. Prevention of mere speculating and encouragement for the formation of *bona fide* working mining companies. For that purpose the mining right must be declared entirely independent of the surface right, and this mining right must not be sold, as to do so allows speculators to buy at very low figures large tracts of "mineral lands" which they retain without working them and which they sell only at very high prices; thus delaying the development of our mining industry and hindering the surface and underground explorations; and, the value of our mining districts remains unknown, which is very damaging in an immense new country like ours where the discovery of very rich mining districts may be anticipated every day.

By giving to every one offering sufficient guarantee, when a discovery has been made and when he is first to apply for it, a permanent lease (disposable and transferable as in the case of any other property) of the mining right under the area of land asked for by him, subject however to the following conditions: *

Conditions.

(*a*). The lessee shall pay to the discoverer the royalty stated above

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* That would place a lessee exactly on the same footing as an owner in fee simply would be, excepting the condition of working the property necessary to prevent speculation.

except if they can agree upon a fixed sum to be paid in the first year of the lease.

(*b*). To prevent the monopoly of mining rights on too large an extent of lands, larger than can be worked actively to the best interest of the country, that is to say, so as to restrict the areas under which mining rights will be leased to companies within reasonable limits, and to prevent companies from acquiring mining leases simply with the idea of speculating in or selling them at a given time, which would, like the system of to day, ruin the mining industry:

The lessee, commencing 6 months after the day of tbe granting of the lease, shall pay an annual penalty of $100 per acre of land under which the mineral substance shall not have been during that year sufficiently worked. Every acre will be considered as insufficiently worked for which an annual average sum of $100 shall not have been expended. This annual average expenditure will be arrived at in taking into account in the total all expenditure in any work connected with the mine; this total divided by 100 will give the number of acres of the lease sufficiently worked.

Every person having a lease will be permitted to relinquish it on demand, but so long as he retains it he will be subject to the above conditions.

If this penalty (*b*) is not paid within six months after becoming due the lease shall he considered forfeited.

(*c*). The lessee shall be entitled and obliged to buy a sufficient area of land necessary for the surface requirements of the mine (plant, offices, dumping grounds, etc.); but, no more than is absolutely necessary if the owner of the soil has any objection; the prices being the ordinary price of the Crown Lands department if on public lands, or being fixed by arbitration, at the ordinary prices of lands in that locality, if on appropriated lands.

(*d*). All mines shall be subject to inspection by duly appointed officers of the government so as to assure the proper working of the mine according to the conditions of the lease, the preservation of the surface —always endangered by subterranean works;—and also, the safety of mining workmen and the due enforcement of the laws and regulations respecting mines and minerals.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA
ALFRED R. C. SELWYN, LL.D., F.R.S., F.G.S., DIRECTOR.

CHEMICAL CONTRIBUTIONS

TO THE

GEOLOGY OF CANADA,

FROM THE

LABORATORY OF THE SURVEY.

BY

G. CHRISTIAN HOFFMANN, F. Inst. Chem.,
Chemist and Mineralogist to the Survey.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.
1885.

ALFRED R. C. SELWYN, ESQ., LL.D., F.R.S., F.G.S.,

Director of the Geological and Natural History Survey of Canada.

SIR,—I beg to present herewith my report upon the work carried out in the Laboratory of the Survey during the year ending August 31, 1885. It embraces only such analyses and examinations as were considered likely to prove of general interest. As will be seen, attention has been mainly directed to the examination of such minerals, etc., etc., as were deemed likely to prove of economic value.

Of the work here recorded, Analyses 3, 4, 5, 6, and 8—Assays 6 to 13 inclusive, and Examination 2, under Miscellaneous Minerals, were conducted by Assistant Chemist, Mr. Frank D. Adams.

I have the honor to be,

Sir,

Your obedient servant,

G. CHRISTIAN HOFFMANN.

OTTAWA, August 31, 1885.

CHEMICAL CONTRIBUTIONS

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COALS AND LIGNITES.

[In continuation of the previous report on this subject, Report of Progress, 1882-83-84,—Report M.]

The fuels in question are, with the exception of No. 49, all from the North-West Territory.

38.—LIGNITE.—From the Saskatchewan Coal Mining and Transportation Company's mine (from what part of the workings could not be ascertained), South Saskatchewan, north bank, seven miles west of Medicine Hat. Main seam. Seam about five feet thick. Geological position—Cretaceous, Belly River series. Received from D. B. Woodworth, Esq., M.P. Lignite from the South Saskatchewan.

Structure somewhat coarse lamellar—moderately compact; with the exception of one layer it presented throughout a general appearance of great uniformity alike in texture, color, and lustre; it contains an occasional interstratified layer of mineral charcoal, likewise thin plates of gypsum and numerous minute crystalline aggregations of pyrite; it has also a large amount of a lemon-yellow, occasionally brownish-yellow, sub-transparent to transparent resin, chiefly in small particles, diffused through its substance; color greyish-black; lustre resinous; fracture uneven; apart from the layers of mineral charcoal, does not soil the

Lignite from the South Saskatchewan, [continued.]

fingers; powder black, with a slight brownish tinge; it communicates a deep brownish-red color to a boiling solution of caustic potash. The layer referred to above, as differing in general appearance from the rest of the specimen, averaged, in one fragment weighing fifteen pounds, seven-eighths of an inch in thickness; the material composing it was very compact, exhibited, although but faintly, a delicate ligneous structure, had a black color, a resinous lustre, and a conchoidal fracture. This band was coated on either side by a moderately thick, firmly attached, layer of mineral charcoal. It would appear to consist of the more solid portion—trunk or branch—of some of the vegetable matter from which the bed of lignite has been derived. This lignite when first received was tolerably hard and firm, and remained so for some little time; on further exposure to the atmosphere, however, it became more or less fissured, and hence somewhat tender.

Analyses of.

Analyses by slow and fast coking gave:

	Slow coking.	Fast coking.
Hygroscopic water	19.90	19.90
Volatile combustible matter	30.88	33.33
Fixed carbon	44.03	41.58
Ash	5.19	5.19
	100.00	100.00
Coke, per cent	49.22	46.77
Ratio of volatile combustible matter to fixed carbon	1:1.42	1:1.25

It yields—both by slow and fast coking, a non-coherent coke; the gases evolved during coking burnt with a yellowish, slightly luminous, almost smokeless flame. The ash has a brownish-yellow color,—at a bright red heat it becomes slightly agglutinated, at a most intense red heat it becomes fritted.

Lignite from the South Saskatchewan.

39.—Lignite.—Subsequent to the examination of the preceding specimen, another sample of the lignite from this mine was received for analysis. This sample was taken from No. 6 level, three hundred and twenty feet from the entrance. It was accompanied by a statement to this effect—"The coal in all the levels at this mine is pretty much of the same character; in the upper part of the seam is a band of coal a few inches thick, like Parrot coal. I send specimens of this with the other."

The material constituting what is here referred to as a band in the upper part of the seam, differed somewhat in character; one portion fully answered to the description given of the layer alluded to when describing the previous specimen, as differing in

general appearance from the rest of that specimen, the remainder exhibited, although somewhat indistinctly, a very fine lamellar structure, was compact, had a greyish-black color, a resinous lustre, and an uneven, occasionally imperfectly conchoidal, fracture.

The description given of the preceding specimen and the remarks made in regard to it, apply also to this specimen, which, as will be seen, also differed from it but very slightly in composition.

Analyses by slow and fast coking gave: Analyses of.

	Slow coking.	Fast coking.
Hygroscopic water	20.54	20.54
Volatile combustible matter	29.94	33.26
Fixed carbon	44.47	41.15
Ash	5.05	5.05
	100.00	100.00
Coke, per cent	49.52	46.20
Ratio of volatile combustible matter to fixed carbon	1:1.48	1:1.24

The character of the coke, color of the ash, and behaviour of the latter at elevated temperatures, was the same as that of the preceding specimen.

40.—Lignite.—From Hay Flat, Wood Mountain, ten and a-half miles east of Wood Mountain Post. Seam six feet thick. Geological position—Laramie. Collected by Mr. R. G. McConnell. Lignite from Hay Flat, Wood Mountain.

Structure, for the most part, moderately fine lamellar, it contains, however, an occasional somewhat thick, irregular shaped layer of dense material, also, and more immediately associated with the latter, a few thin seams of a dull chocolate-brown colored substance—tolerably compact; color greyish-black; lustre subresinous; fracture uneven; the dense material has a pure black color, a resinous to vitreous lustre, and a more or less conchoidal fracture; does not soil the fingers; powder dark brown, inclining to brownish-black; it communicates a deep brownish-red color to a boiling solution of caustic potash; by exposure to the air becomes somewhat fissured and hence tender.

Analyses by slow and fast coking gave: Analyses of.

	Slow coking.	Fast coking.
Hygroscopic water	13.73	13.73
Volatile combustible matter	36.22	38.91
Fixed carbon	41.23	38.54
Ash	8.82	8.82
	100.00	100.00
Coke, per cent	50.05	47.36
Ratio of volatile combustible matter to fixed carbon	1:1.14	1:0.99

It yields—both by slow and fast coking, a non-coherent coke; the gases evolved during coking burnt with a yellowish, slightly luminous, almost smokeless flame. The ash has a light brownish-grey color, it does not become agglutinated at a bright red heat, but at a most intense red heat it forms a slaggy mass.

Lignite from Crowfoot Creek Bow River.

41.—Lignite.—From a shaft sunk on the bank of Crowfoot Creek, about five miles from its entry into Bow River, section 7, township 22, range xx, west of 4th principal meridian. Depth of shaft to bottom of coal, one hundred and thirty-five feet. Seam nine feet thick, with two shaly partings of twelve and three inches respectively. Geological position—Laramie.

[Specimens Nos. 12 and 14 of the previous report—Report of Progress 1882–83–84, pp. 19–21 M.—are from natural exposures of the same seam, the former being about eight and the latter about six miles south of the shaft.]

Structure somewhat fine lamellar—compact; it contains, interstratified, more or less disconnected, lenticular layers of dense, pitch-black, highly lustrous material, and an occasional layer of mineral charcoal; lustre sub-resinous to resinous; shows well defined planes of cleat; color greyish-blach to black, that of the powder, black, with a faint brownish tinge; it communicates a deep brownish-red color to a boiling solution of caustic potash; apart from the layers of mineral charcoal, does not soil the fingers; by exposure to the air becomes slightly fissured, but is on the whole tolerably hard and firm. In appearance it resembles some varieties of coal of the Carboniferous system.

Analyses of.

Analyses by slow and fast coking gave:

	Slow coking.	Fast coking.
Hygroscopic water	10.35	10.35
Volatile combustible matter	30.97	34.40
Fixed carbon	43.04	39.61
Ash	15.64	15.64
	100.00	100.00
Coke, per cent	58.68	55.25
Ratio of volatile combustible matter to fixed carbon	1:1.39	1:1.15

It yields—both by slow and fast coking, a non-coherent coke; the gases evolved during coking burnt with a yellow, luminous, slightly smoky flame. The ash has a very light brownish-grey color—exposed to a bright red heat it does not become agglutinated, at a most intense red heat it becomes slightly fritted.

42.—Lignite.—On branch of Willow Creek, six miles south-east of head of mountain, Cypress Hills. Seam four feet thick. Geological position—Laramie. Collected by Mr. R. G. McConnell. Lignite from Willow Creek, Cypress Hills.

Structure fine lamellar—tolerably compact; it contains an occasional interstratified layer of mineral charcoal; color black; lustre, sub-resinous to resinous; fracture uneven; powder black, with a faint brownish tinge; it communicates a deep brownish-red color to a boiling solution of caustic potash; by exposure to the air splits along the line of bedding and falls to pieces.

Analysis by fast coking gave: Analysis of.

Hygroscopic water	16.37
Volatile combustible matter	35.58
Fixed carbon	37.23
Ash	10.82
	100.00
Coke, per cent	48.05
Ratio of volatile combustible matter to fixed carbon	1:1.05

It yields a non-coherent coke; the gases evolved during coking burnt with a pale yellowish, feebly luminous, smokeless flame. The ash has a pale greenish-grey color—exposed to a bright red heat it does not agglutinate, but at a most intense red heat it fuses to a vitrified mass.

43.—Lignitic Coal—From the north edge of Milk River Ridge, one and a-half mile east of Fossil Coulée. Seam eighteen inches thick. Southern extension of "Coal Bank's" main seam. Geological position—Cretaceous, base of Pierre. Collected by Dr. G. M. Dawson. Lignitic coal from Milk River Ridge.

[This exposure of the Coal Banks main seam is thirty-three miles distant, in a south-southeasterly direction, from Coal Banks, whilst that on the St. Mary River is about ten miles south of Coal Banks—vide specimens Nos. 26 and 27 of former report, Report of Progress 1882-83-84, pp. 30-31 M. Specimen No. 26 was taken from the level (how far in from the entrance was not stated) commenced during the summer of 1882 at Sheran's mine, which is on the left bank of the river at Coal Banks, the North-western Coal and Navigation Company's mine (Lethbridge mine), being on the opposite side of the river. Specimen No. 27, from the St. Mary River—thickness of the seam, at the point indicated, three feet eight inches.]

Structure somewhat fine lamellar, tolerably compact; color greyish-black, almost pure black; lustre resinous; intersected by

Lignitic coal from Milk River Ridge, continued.

numerous thin films of calcite and pyrite; does not soil the fingers; powder black with a brownish tinge; it communicates a brownish-red color to a boiling solution of caustic potash; does not readily become fissured when exposed to ths air, and may, on the whole, be said to be a firm coal.

Analyses of.

Analyses by slow and fast coking gave:

	Slow coking.	Fast coking.
Hygroscopic water	5.58	5.58
Volatile combustible matter	31.81	37.77
Fixed carbon	55.81	49.85
Ash	6.80	6.80
	100.00	100.00
Coke, per cent	62.61	56.65
Ratio of volatile combustible matter to fixed carbon	1:1.75	1:1.32

It yields—by slow coking, a non-coherent coke,—by fast coking a slightly fritted coke; the gases evolved during coking burnt with a yellow, luminous, somewhat smoky flame. The ash has a pale dirty reddish-brown color,—exposed to a bright red heat it becomes slightly sintered, at a most intense red heat it forms a more or less slaggy mass.

Coal from Crow Nest Pass, Rocky Mountains.

44.—Coal—From Crow Nest Pass, Rocky Mountains. Middle seam. Seam two feet ten inches thick. Geological position—Cretaceous, Collected by Dr. G. M. Dawson.

Structure fine lamellar, the lines of bedding are, however, almost obliterated—compact; shows slickensides; color black; lustre vitreous; hard and firm; fracture uneven; scarcely soils the fingers; powder almost black; it communicates a brownish-yellow color to a boiling solution of caustic potash; resists exposure to the air; in appearance it closely resembles some varieties of coal of the Carboniferous system.

Analysis of.

Analysis by fast coking gave:

Hygroscopic water	1.82
Volatile combustible matter	24.55
Fixed carbon	51.22
Ash	22.41
	100.00
Coke, per cent	73.63
Ratio of volatile combustible matter to fixed carbon	1 : 2.09

It yields a compact, firm, coherent coke; the gases evolved during coking burnt with a yellow, luminous, smoky flame. Color

of the ash, white, with a faint greyish tinge—exposed to a bright red heat it remains unaffected, at a most intense red heat it becomes slightly agglutinated.

45.—Coal.—From the Red Deer River, Rocky Mountains. Northern continuation of Cascade River anthracite trough. Seam broken up where exposed, and the thickness uncertain, but at least several feet. Collected by Dr. G. M. Dawson. Coal from the Red Deer River, Rocky Mountains.

Structure very fine lamellar, the lines of bedding are not unfrequently indistinct or almost obliterated—compact; color black, but not pure black; lustre resinous; hard and firm; fracture uneven; does not soil the fingers; powder almost black; it communicates a pale brownish-yellow color to a boiling solution of caustic potash; resists exposure to the air; in appearance it closely resembles some varieties of coal of the Carboniferous system.

Analysis by fast coking gave: Analysis of.

Hygroscopic water	02.9
Volatile combustible matter	29.26
Fixed carbon	62.95
Ash	4.89
	100.00
Coke, per cent	67.84
Ratio of volatile combustible matter to fixed carbon	1:2.15

It yields a compact, firm, coherent coke; the gases evolved during coking burnt with a yellow, luminous, smoky flame. Color of the ash, white, with a faint reddish tinge—when exposed to a bright red heat it remains unaffected, at a most intense red heat it becomes just perceptibly fritted.

46.—Coal.—From the South Fork of the Old Man River, four miles above the south branch, Rocky Mountains. Seam nine and three-quarters feet thick. Geological position—Cretaceous. Collected by Dr. G. M. Dawson—and in such wise as to represent a fair average of the entire face of the seam. Coal from the Old Man River, South Fork, Rocky Mountains.

Structure very fine lamellar, the lines of bedding, which are very numerous and close together, are not always very distinct—compact; color greyish-black; lustre sub-resinous to resinous; hard and firm; fracture uneven; slightly soils the fingers; powder almost black; it communicates a pale brownish-yellow color to a boiling solution of caustic potash; resists exposure to the air; in appearance it is not unlike some varieties of coal of the Carboniferous system.

Coal from the Old Man River, South Fork, Rocky Mountains. Analysis of.

Analysis by fast coking gave:

Hygroscopic water	1.93
Volatile combustible matter	23.23
Fixed carbon	57.50
Ash	17.34
	100.00
Coke, per cent	74.84
Ratio of volatile combustible matter to fixed carbon	1 : 2.47

It yields a firm, coherent coke; the gases evolved during coking burnt with a yellow, luminous, somewhat smoky flame. Color of the ash, white—it does not show the least disposition to agglutinate even when exposed to a most intense red heat.

Coal from Oyster Creek, North Fork, Old Man River.

47.—Coal.—From Oyster Creek, north-west branch of the North Fork of the Old Man River. From one of numerous thin seams. Geological position—Laramie. Collected by Dr. G. M. Dawson.

Structure very fine lamellar, the lines of bedding, which are very numerous and close together, are almost obliterated—compact; color greyish-black; lustre sub-resinous to resinous; hard and firm; fracture uneven—it not unfrequently breaks into more or less rhombic fragments; does not soil the fingers; powder brownish-black; it communicates a very pale brownish-yellow color by a boiling solution of caustic potash; resists exposure to the air. The specimen in question was, in parts, very much soiled with argillaceous matter, and to this circumstance may be attributed the large percentage of incombustible matter which this sample of the fuel was found to contain.

Analysis of.

Analysis by fast coking gave:

Hygroscopic water	4.03
Volatile combustible matter	31.82
Fixed carbon	39.46
Ash	24.69
	100.00
Coke, per cent	64.15
Ratio of volatile combustible matter to fixed carbon	1 : 1.24

It yields a firm, coherent coke; the gases evolved during coking burnt with a yellow, luminous, very smoky flame. Color of the ash, pale reddish-brown—exposed to a bright red heat it does not become agglutinated, at a most intense red heat it becomes fritted.

Coal from the Old Man River, North Fork, Rocky Mountains.

48.—Coal.—From north-west branch of the North Fork, Old Man River, Rocky Mountains. Seam eight feet (or more) thick. Geological position—Cretaceous. Collected by Dr. G. M. Dawson—

and in such a manner as to represent a fair average of the entire face of the seam.

Compact; shows slickensides; color greyish-black; lustre sub-resinous to resinous; firm; fracture uneven; slightly soils the fingers; powder almost black; it communicates a very pale brownish-yellow color to a boiling solution of caustic potash; resists exposure to the air; in appearance it resembles some varieties of coal of the Carboniferous system.

Analysis by fast coking gave: Analysis of.

Hygroscopic water	1.24
Volatile combustible matter	24.62
Fixed carbon	66.61
Ash	7.53
	100.00
Coke, per cent	74.14
Ratio of volatile combustible matter to fixed carbon	1:2.70

It yields a firm coherent coke; the gases evolved during coking burnt with a yellow, luminous, smoky flame. Color of the ash, white—when exposed to a bright red heat it remains unaffected, at a most intense red heat it becomes fritted. Coal from Martin Creek, Rocky Mountains.

49.—Coal.—From second crossing, Martin Creek, Rocky Mountains, British Columbia. Seam about two feet thick. Geological position—Cretaceous. Collected by Dr. G. M. Dawson.

Structure very fine lamellar, the lines of bedding are not unfrequently very indistinct or altogether obliterated—compact; color black; lustre resinous; hard and firm; fracture uneven; does not soil the fingers; powder greyish-black; it communicates a very pale brownish-yellow color to a boiling solution of caustic potash; resists exposure to the air; in appearance it is not unlike some varieties of coal of the Carboniferous system. The sample received for examination was here and there coated with earthy matter which was not readily removable—this would account for the large percentage of incombustible matter which this particular specimen was found to leave on ignition.

Analysis by fast coking gave: Analysis of.

Hygroscopic water	2.12
Volatile combustible matter	26.92
Fixed carbon	43.48
Ash	27.48
	100.00
Coke, per cent	70.96
Ratio of volatile combustible matter to fixed carbon	1:1.61

It yields a compact, very firm, coherent coke; the gases evolved during coking burnt with a yellow, luminous, very smoky flame. The ash has a very pale reddish-brown color—when exposed to a bright red heat it does not agglutinate, at a most intense red heat it becomes slightly sintered.

Semi-anthracite from the Bow River, Rocky Mountains.

50.—Semi-anthracite.—From the Bow River, right bank, about one and a-half mile from Canmore Station, Canadian Pacific Railway. Seam about one foot thick. Southern continuation of Cascade River anthracite trough. Collected by Dr. G. M. Dawson.

Structure lamellar, the lines of bedding are, however, not unfrequently very indistinct—compact; shows slickensides; it contains an occasional very thin layer of mineral charcoal; color black, in parts iridescent; lustre for the most part bright, that of some of the denser layers sub-metallic; brittle; fracture, on the whole, uneven, that of the more lustrous bands more or less conchoidal; powder black; it communicates only a just perceptible yellowish tinge to a boiling solution of caustic potash; when suddenly heated it decrepitates somewhat.

Analysis of.

Analysis by fast coking gave:

Hygroscopic water	1.60
Volatile combustible matter	12.23
Fixed carbon	82.32
Ash	3.85
	100.00
Coke, per cent	86.17
Ratio of volatile combustible matter to fixed carbon	1:6.73

It yields a non-coherent coke; the gases evolved during coking burnt with a yellowish, somewhat luminous, almost smokeless flame. Color of the ash,—reddish-white, exposed to a bright red heat it does not become agglutinated, at a most intense red heat it becomes slightly sintered.

Semi-anthracite from the Cascade River. Rocky Mountains.

51.—Semi-anthracite.—From Cascade River, near Bow River, about a quarter of a mile from the line of the Canadian Pacific Railway. Upper thick seam near Hughes' mine. Seam three feet ten inches thick. Geological position—Cretaceous. Collected by Dr. G. M. Dawson.

[The specimen of semi-anthracite, of which an analysis (No. 37) is given in the previous report, Report of Progress, 1882-83-84, p. 41 M., came from the Cascade mine (Moberly's), which is near Banff Station, on the Canadian Pacific Railway. The Hughes' mine, now Stewart's mine, above referred to, is about three miles distant from this mine.]

Structure lamellar, made up of irregularly alternating layers of a greyish-black, somewhat bright, and dense jet-black coal of brilliant lustre—compact; in parts iridescent; brittle; fracture, on the whole, uneven, that of the denser and more lustrous layers, more or less conchoidal; powder black; it communicates only a just perceptible yellowish tinge to a boiling solution of caustic potash; hard and firm; resists exposure to the air; when suddenly heated it decrepitates, but not very considerably.

Semi-anthracite from the Cascade River, Rocky Mountains, cont.

Analysis by fast coking gave:

Analysis of.

Hygroscopic water	1.04
Volatile combustible matter	9.15
Fixed carbon	87.18
Ash	2.63
	100.00
Coke, per cent	89.81
Ratio of volatile combustible matter to fixed carbon	1:9.53

It yields a non-coherent coke; when heated in a covered crucible it yields a small amount of a pale yellow smokeless flame of feeble luminosity. Color of the ash, white—it does not agglutinate at a bright red heat, and even at a most intense red heat becomes only very slightly fritted.

Of the foregoing, No. 41 may be regarded as a lignite of superior quality; it is tolerably hard and firm, would, when freshly won, bear transportation, and might be advantageously employed for domestic and other heating purposes. The same remarks apply to No. 43. Numbers 44 to 51 inclusive, are all good firm fuels, do not, apparently, break down on exposure to the weather, and might be expected to resist the friction incident to carriage, without serious waste by reduction to fine material. Numbers 44 to 49 inclusive, burn with a good flame, yield firm coherent cokes (even in the case of Nos. 44, 47, and 49, which contained an unusually large proportion of inorganic matter—the presence of which has been, in so far as numbers 47 and 49 are concerned, explained under their respective analyses) and are all good serviceable fuels, and well adapted for household purposes, for raising steam, and gas-making; numbers 47 and 49 in particular would, judging from the character of the flame of the gases evolved during coking, afford good material for the latter purpose. Numbers 50 and 51 differ materially from all the foregoing in chemical composition, the latter very closely resembles No. 37 of the previous report; it is an excellent fuel, and will no doubt, as in that instance, be

General remarks on character and economic value of these fuels.

found to possess a high evaporative power, and in consequence prove valuable for the generation of steam.

NATURAL WATERS.

Spring water from the seigniory of Longueuil.

1.—Spring water from the seigniory of Longueuil, Soulanges County, Province of Quebec. Examined for Mr. J. E. Juaire. The spring from which this water was taken is said to be situated about three-quarters of a mile from the village of River Beaudette, and forty feet from the bank of the Beaudette River.

It was described as filling a natural basin of sixty by forty feet, into which the water rises through some ten or twelve holes at the bottom, and from which the flow was estimated to be about four hundred and fifty gallons a minute. This spring rises from the Cambro-Silurian—Chazy.

The sample of this water sent for examination was perfectly clear and bright; quite colorless, even when viewed in a column two feet in length; was devoid of odor and any marked taste, either at the ordinary temperature or after having been warmed. The specific gravity at $15^{\circ}\cdot5$C., was found to be 1000·16.

The precipitate produced by boiling consisted of carbonate of lime and carbonate of magnesia with traces of ferric oxide. The amount of carbonic acid found is in excess of that required to form bi-carbonates.

Analysis of.

Analysis gave as follows, for 1000 parts:

Potassa	.0015
Soda	.0045
Lime	.0473
Magnesia	.0170
Alumina	—
Ferrous oxide	traces
Chlorine	.0013
Sulphuric acid	.0194
Carbonic acid	.1094
Silica	.0092
	.2096
Less oxygen equivalent to chlorine	.0003
	.2093

The foregoing acids and bases are most probably combined in the water as follows:

Analysis of spring water from the seigniory of Longueuil, continued.

(Carbonates being calculated as mono-carbonates, and all the salts estimated as anhydrous.)

Chloride of sodium	.0021
Sulphate of potassa	.0028
" soda	.0078
" lime	.0233
Carbonate of lime	.0673
" magnesia	.0357
" iron	traces
Silica	.0092
	.1482
Carbonic acid, half-combined	.0483
" , free	.0128
	.2093

An Imperial gallon of this water would contain:

(Carbonates calculated as anhydrous bi-carbonates, and the salts without their water of crystallisation.)

	Grains.
Chloride of sodium	.147
Sulphate of potassa	.196
" soda	.546
" lime	1.631
Bi-carbonate of lime	6.783
" magnesia	3.808
" iron	traces
Silica	.644
	13.755
Carbonic acid, free	896
	14.651

Saline water, Rosenfeld Station, Manitoba.

2.—Saline water from an artesian well at Rosenfeld Station, on the line of the Canadian Pacific Railway, Manitoba. The sample was obligingly procured and forwarded—April, 1885,—by J. M. Egan, Esq., at the instance of Dr. G. M. Dawson. The latter gentleman informs me that the brine was first struck at a depth of two hundred and thirty-five feet, that the flow continued to increase as the boring progressed, rising to the surface and forming a strong flowing well.

The water, when received, contained a small quantity of reddish-brown colored suspended matter, which, for 1000 parts by weight of the brine, amounted to 0·0103, and of this, 0·0067 consisted of ferric oxide, which latter had, doubtless, at one time been present in the water as ferrous carbonate. The filtered

Saline water, Rosenfeld Station, Manitoba, continued.

water was perfectly colorless; taste, strongly saline with a very slightly bitter after taste; it did not affect the color of turmeric paper, but exhibited a slightly alkaline reaction with reddened litmus paper. The reaction for boric acid, although faint, was quite distinct. Bromine and iodine are both present—the amount of the former exceeding, apparently, that of the latter,—but owing to a total insufficiency of material, the determination of the respective amounts of these constituents, could not be carried out. The specific gravity of the water, at 15°·5C., was found to be 1032·86. Its analysis gave as follows, for 1000 parts by weight:—

Analysis of.

Potassa	.2640
Soda	19.3545
Lime	1.9538
Magnesia	.8252
Ferrous oxide	traces
Sulphuric acid	2.4418
Boric acid	traces
Carbonic acid	.0342
Silica	.0126
Chlorine	23.8783
Bromine	undet.
Iodine	undet.
	48.7644
Less oxygen equivalent to chlorine	5.3871
	43.3773
Less oxygen equivalent to bromine and iodine	unascertained.

Total dissolved solid matter, by direct experiment, dried at 180°C., 43·4280.

It may be reasonably assumed that the foregoing acids and bases exist in the water in the following state of combination:

(The carbonate being calculated as mono-carbonate, and all the salts estimated as anhydrous.)

Chloride of potassium	.4179
" sodium	36.4971
" calcium	.3982
" magnesium	1.7225
Sulphate of lime	4.1511
Borate of soda	traces
Carbonate of lime	.0777
" iron	traces
Bromide of magnesium	undet.
Iodide of magnesium	undet.
Silica	.0126

The proportion of magnesium assumed to be present as bromide and iodide, amounts to 0·0596.

This water, in common with those of Hallowell, St. Catherines, and Ancaster, belongs to the first class of Dr. T. Sterry Hunt's classification of mineral waters (Geology of Canada, 1863, p. 531). It almost equals in strength the strongest of these saline waters, —viz., one from Hallowell, which was found by Dr. T. S. Hunt to contain, in 1000 parts, 38.7315 of chloride of sodium,—and would be far superior to either of them for the manufacture of salt, in that it contains a very much smaller amount of the deliquescent chlorides of calcium and magnesium.

Saline water, Rosenfeld Station, Manitoba, continued.

3.—Water from a spring at Halowell Grant, about eight or nine miles north of the town of Antigonish, Antigonish County, Nova Scotia. The sample was kindly procured and forwarded—October, 1884—by Henry P. Hill, Esq., of Antigonish. The spring in question rises from rocks which are most probably of Lower Carboniferous age.

Water from Halowell Grant, Nova Scotia.

Mr. Hugh Fletcher, at whose instance the sample in question was collected, informs me that this water is drunk for a variety of ailments, and, as it is asserted, with beneficial results.

It was found to contain a very appreciable amount of suspended matter. This was removed by filtration. The filtered water, when viewed in a column two feet in length, was found to have a faint brownish tinge. It was inodorous and devoid of any special taste. The suspended matter of 1000 parts of the water contained an amount of iron corresponding to ·0021 of ferric oxide, the same was, in all probability, at one time present in the water as ferrous carbonate. The specific gravity of the water at 15°·5C. was found to be 1000·53.

Agreeably with the results of an analysis conducted by Mr. Frank D. Adams, the filtered water contained in 1000 parts:—

Analysis of.

Potassa	.0087
Soda	.0420
Lime	.1768
Magnesia	.0141
Alumina	.0005
Ferrous oxide	.0015
Sulphuric acid	.1993
Phosphoric acid	traces.
Carbonic acid	.0989
Silica	.0081
Chlorine	.0547
Organic matter	traces.
	.6046
Less oxygen equivalent to chlorine	.0123
	.5923

Water from HalowellGrant, Nova Scotia. Analysis of, continued.

The foregoing acids and bases are most probably combined in the water as follows:—

(Carbonates calculated as mono-carbonates, and all the salts estimated as anhydrous.)

Chloride of potassium	.0137
" sodium	.0793
Sulphate of lime	.3388
Carbonate of lime	.0666
" magnesia	.0296
" iron	.0024
Alumina	.0005
Silica	.0081
Phosphoric acid	traces.
Organic matter	traces.
	.5390
Total dissolved solid matter, by direct experiment, dried at 180°C., 0.5383.	
Carbonic acid, half-combined	.0457
" , free	.0075
	.5922
Chlorine in excess of that required by the potassium and sodium	.0001
	.5923

An Imperial gallon of the water would contain:—

(Carbonates calculated as anhydrous bi-carbonates, and the salts without their water of crystallisation.)

	Grains.
Chloride of potassium	.959
" sodium	5.551
Sulphate of lime	23.716
Bi-carbonate of lime	6.713
" magnesia	3.157
" iron	.231
Alumina	.035
Silica	.567
Phosphoric acid	traces.
Organic matter	traces.
	40.929
Carbonic acid, free	.525
	41.454

This water belongs to the sixth class of Dr. T. Sterry Hunt's classification of mineral waters. (Geology of Canada, 1863, p. 531.)

4.—Water from Silver Islet mine, Lake Superior, Ontario. It was collected by Capt. Trethewey at the instance of Dr. A. R. C. Selwyn. Water from Silver Islet Mine, Lake Superior.

The islet—which lies at a distance of about half a mile from the north shore of the lake, and six miles east of Thunder Cape—consists of part of a dyke of diorite which cuts the nearly horizontal dark colored slates of the Animikie series. It is traversed by a vein consisting of calcite, dolomite, fluorite, and quartz. The silver occurs both native and as argentite. Other associated minerals are tetrahedrite, domeykite, galenite, sphalerite, pyrite, chalcopyrite, erythrite, and annabergite. The workings at the date of collection of the water, summer, 1882, had been carried to a depth of about eleven hundred feet.

The water contained some suspended matter which on examination was found to be, for the most part, of an argillaceous nature. This was removed by filtration. The filtered water was colorless and odorless; it tasted strongly saline, with a slightly bitter after-taste; reaction, neutral. The specific gravity of the water at 15°·5C. was 1028·48.

An analysis by Mr. Frank D. Adams showed it to contain—in 1000 parts by weight:— Analysis of.

Potassa	.2895
Soda	8.9138
Lime	8.8186
Magnesia	.5451
Sulphuric acid	.0395
Carbonic acid	?
Silica	.0540
Chlorine	22.3057
	40.9662
Less oxygen equivalent to chlorine	5.0323
	35.9339

Total dissolved solid matter, by direct experiment, dried at 180°C., 35·9566.

The foregoing acids and bases are most probably combined in the water as follows:—

(Carbonates calculated as mono-carbonates, and all the salts estimated as anhydrous.)

Chloride of potassium	.4582
" sodium	16.8098
" calcium	17.0867
" magnesium	1.2937
Sulphate of lime	.0672
Carbonate of lime	.2936
Silica	.0540

Water from Silver Islet Mine, Lake Superior, cont.

The water was found to contain a trace of manganese and a minute trace of cobalt. Alumina and iron were absent. The quantity of the water at the disposal of the operator was too limited to admit of its being tested for bromine and iodine. There is an excess of 0.1644 lime; this might, not improbably, be present as carbonate—it has been thus represented above.

This water belongs to the first class of Dr. T. Sterry Hunt's classification of mineral waters (Geology of Canada, 1863, p. 531.)

Iron ores.

IRON ORES.

Magnetite from Digby, Nova Scotia.

5.—Magnetic iron-ore found on the property of Mr. R. W. Bulkeley, about two miles from the port of Digby, on the road leading from Digby to Broad Cove, Digby County, Nova Scotia. It occurs in Triassic trap. The locality has been examined (November 1884) by Mr. R. W. Ells, of this Survey, and he is inclined to think that the ore occurs in sufficient quantity to be of economic importance. The specimen examined was received from Colin Campbell, Esq., of Ottawa.

Massive, structure for the most part compact, occasionally, here and there, finely crystalline: it contained numerous inclusions of milky-white, more rarely colorless, transparent quartz. Color, black with a faint reddish-brown tinge; streak, brownish-black. Readily attracted by the magnet.

Partial analysis of.

Determinations—by Mr. F. D. Adams—of the more important constituents gave (after drying at 100°C.—Hygroscopic water = 0.213 per cent,) the following results:

Ferric oxide	52.220
Ferrous oxide	16.376
Titanium dioxide	traces
Phosphoric acid	.072
Sulphur	.021
Insoluble matter	26.872
Metallic iron, total amount of	49.291
Phosphorus	.031
Sulphur	.021

Magnetite from Bagot, Ontario.

6.—Magnetic iron-ore from the thirteenth lot of the tenth range of Bagot, County of Renfrew, Ontario. The specimens here referred to were received from C. F. Gildersleeve, Esq., of Kingston. The one first sent consisted of a single fragment, weighing one pound six ounces, and answered to the following description:

Massive, structure fine-granular—minute octahedral crystals of magnetite, more or less isolated or in small aggregations, occur

scattered through the mass. Color, dark steel-grey. Streak, reddish-brown. Readily attracted by the magnet. It consisted, apparently, of a mixture of crystalline magnetite and hematite. Magnetite from Bagot, Ontario, continued.

This was subsequently replaced by another sample which was in the form of moderately coarse powder and stated to consist of material taken from various parts of the exposure. As an analysis of this was deemed more likely to convey some idea of the general quality of the ore than that of one of the preceding specimen, it was the one selected for examination. It was strongly magnetic and afforded a black streak.

A partial analysis—by Mr. F. D. Adams—showed it to contain (after drying at 100°C.—Hygroscopic water = 0.104 per cent.) as follows: Partial analysis of.

Ferric oxide	57.354
Ferrous oxide	25.463
Titanium dioxide	none
Phosphoric acid	.163
Sulphur	.207
Insoluble matter	14.590
Metallic iron, total amount of	59.953
Phosphorus	.071
Sulphur	.207

The ratio of ferric oxide to ferrous oxide in this sample of the ore, is almost identical with that required by theory for magnetite. The insoluble matter consisted, for the most part at least, of the variety of hornblende known as actinolite.

COPPER ORES.

Copper ores.

7.—From the eleventh lot of the fifth concession of the township of McKim, District of Nipissing, Ontario. Collected by Dr. A. R. C. Selwyn. Copper-pyrites from McKim, District of Nipissing, Ontario.

The sample was taken from an exposure in a cutting on the line of the Canadian Pacific Railway, at which place the ore-bearing rock or vein was found to have a width of forty yards: it is reported that the vein has been traced for a considerable distance on both sides of the track. It consisted of magnetic-pyrites and copper-pyrites, in association with a dark-grey fine-grained diorite and a greyish-green chloritic schist; a few of the fragments were, in parts, coated with hydrated peroxide of iron. Some specimens of the magnetic-pyrites from this deposit contained numerous flakes of molybdenite; this mineral was not, however, observable in any of the fragments composing the sample under consideration.

Partial analysis of.

It was found to contain:—

After drying at 100° C., (Hygroscopic water = 0.085 per cent.)

Iron	27.35	per cent.
Copper	9.08	"
Sulphur	18.69	"
Insoluble matter—gangue	36.63	"

The above 9.08 copper requires, theoretically, 8.02 of iron and 9.17 of sulphur, therewith forming 26.27 copper-pyrites, the balance of the sulphur 9.52 may, for all practical purposes, be regarded as present in the form of magnetic-pyrites.

This ore was also assayed for gold and silver and with the results stated under Gold and Silver Assays, Assay No. 5.

Manganese ores.

MANGANESE ORES.

Psilomelane from Albert County, New Brunswick.

8.—From Gowland Mountain, Elgin, Albert County, New Brunswick. Forwarded to the Survey by Mr. J. L. Harris.

This specimen consisted of psilomelane in association with a trifling amount of pyrolusite; it contained numerous small angular fragments of a reddish or greyish crypto-crystalline quartzite, much of the ore in consequence assuming the character of a well defined breccia. The specimen, which was made up of numerous fragments, weighed a little over thirty-seven and a-half pounds; the whole of this was reduced to coarse powder and a fair average sample prepared from the same. A partial analysis afforded Mr. F. D. Adams the following results:

Partial analysis of.

After drying at 100° C., (Hygroscopic water = 0.855 per cent.)

Manganese dioxide—available	50.21	per cent.
Ferric oxide	3.06	"
Insoluble residue	33.78	"

Agreeably with the results of a qualitative examination, this ore would appear to contain a very appreciable percentage of baryta.

Gold and silver assays.

GOLD AND SILVER ASSAYS.

Province of New Brunswick.

Province of New Brunswick

1.—The following specimen was examined for G. G. King, Esq., it was not labelled, so that the exact locality is not known—it is presumably from Queen's County.

A white translucent quartz, associated with a small quantity of a dark-grey, almost black shale,—carrying a little iron-pyrites: it was in parts coated with ferric hydrate. Gold and silver assays, cont.

It contained neither gold nor silver.

PROVINCE OF ONTARIO.

Assays Nos. 6 to 13 inc. were conducted by Mr. F. D. Adams.

2.—From the township of Artemisia, Grey County. Examined for T. S. Sproule, Esq. Province of Ontario.

It consisted of a white translucent quartz carrying iron pyrites, the latter constituted, approximately, two-thirds, by weight, of the whole. Weight of specimen, rather more than one ounce. It was found to contain:

Gold............ None.
Silver........... 0.364 of an ounce to the ton of 2,000 lbs.

3.—Specimen of band in centre of vein, Huronian mine, Jackfish Lake, township of Moss, District of Thunder Bay, Lake Superior.

An olive green chloritic schist carrying iron-pyrites, in association with a white translucent quartz. Weight of sample thirteen ounces.

It contained neither gold nor silver.

4.—From location R. 71, Osinawe Lake, west of Partridge Lake, and west-north-west of Thunder Bay, Lake Superior. Received from W. A. Allan, Esq.

The specimen, which was stated to be a fair average of a large bulk of the ore, was made up of numerous small fragments: these consisted for the most part of a milky-white quartz, in parts stained with ferric hydrate, carrying a little galena and iron-pyrites; other fragments consisted of a translucent quartz traversed by numerous fissures filled with ferric hydrate, imparting to the whole a flesh-red color; these fragments also carried a little iron-pyrites. Assays showed it to contain:

Gold............ 2.042 ounces to the ton of 2,000 lbs.
Silver........... 1.225 " " "

5.—From lot eleven, concession five of the township of McKim, District of Nipissing.

This specimen has been described under Copper Ores, Analysis 8. It was found to contain:

Gold............ mere traces.
Silver........... 2.187 ounces to the ton of 2,000 lbs.

Gold and silver assays, cont.

Province of Ontario, cont.

6.—This, and the following seven specimens, were collected by Mr. E. D. Ingall.

Iron-pyrites taken from a three feet vein of quartz, Cape Victoria, Lake Superior.

The pyrites, which was fine to coarse crystalline, separated from associated gangue, was found to contain:

Gold............	0.117 of an ounce to the ton of 2,000 lbs.
Silver...........	7.455 ounces " "

7.—Taken from a quartz band, northern end of Jackfish Bay, Lake Superior.

Finely crystalline iron-pyrites associated with a little copper-pyrites and chlorite. It contained :

Gold............	none.
Silver...........	0.350 of an ounce to the ton of 2,000 lbs.

8.—From an island in Terrace Bay, Lake Superior. Taken from quartz stringers said to carry a considerable proportion of this mineral.

A coarsely crystalline iron-pyrites. Assays gave :—

Gold......	mere traces.
Silver...........	0.204 of an ounce to the ton of 2,000 lbs.

9.—From Heron Bay, Lake Superior.

A rudely banded mixture of greyish translucent quartz, reddish colored felspar, finely crystalline iron-pyrites, and a small quantity of a chloritic mineral.

It contained neither gold nor silver.

10.—From a vein two to six inches thick at Still River, Lake Superior.

A fine crystalline iron-pyrites.

It contained neither gold nor silver.

11.—From Jackfish Bay, north shore of Lake Superior.

An association, in about equal proportions, of greyish translucent quartz and a reddish colored felspar. It contained a trifling amount of finely disseminated iron-pyrites. Assays gave:

Gold........ distinct traces. Silver........ none.

12.—From a location near Lac des Milles Lacs, District of Algoma.

An association of a finely crystalline iron-pyrites and a bluish ferruginous magnesite.

It contained neither gold nor silver.

Gold and silver assays, cont.

Province of Ontario, cont.

13.—Taken from a one foot quartz vein, vicinity of Sault Ste. Marie, District of Algoma.

A fine grained mixture of iron-pyrites and greyish translucent quartz. Assays showed it to contain :

Gold............ trace.
Silver........... 0.292 of an ounce to the ton of 2,000 lbs.

14.—From the Arctic mine, Black Bay, Lake Superior.

A moderately fine crystalline galena—through which was disseminated a little iron-pyrites—in a gangue of quartz, intermixed with which was a trifling amount of a ferruginous dolomite. Weight of specimen, nine and three-quarter ounces. It was found to contain :

Silver...... ....traces.

15.—From Current River, north-west corner of location B, township of McIntyre, Thunder Bay, Lake Superior. Received from J. Dewé, Esq.

Zinc-blende in a gangue consisting of a coarse crystalline calcite, a light grey shale and a little quartz. Weight of specimen, two pounds one ounce. It contained:

Silver........... 0.073 of an ounce to the ton of 2,000 lbs.

NORTH-WEST TERRITORY.

North-west Territory.

16.—From Ghost River, about fifty miles west of Calgary.

A dark, faintly purplish, grey colored limestone, carrying a large amount of iron-pyrites. Weight of specimen, thirteen ounces. Assays showed it to contain:

Gold............ traces.
Silver........... 0.729 ounce to the ton of 2,000 lbs.

17.—From Bow River, Rocky Mountains. Received from Mr. Olef Johnson.

Copper-glance, in parts coated with green carbonate of copper, associated with a small quantity of calcite and quartz. Weight of specimen, six and a-half ounces. It was found to contain:

Gold............ traces.
Silver........... 9.989 ounces to the ton of 2,000 lbs.

18.—From "Storm" or "Copper" Mountain, Rocky Mountains, western part of the district of Alberta. Collected by Dr. G. M. Dawson.

A gossan. Weight of specimen, six and three-quarter ounces.

It contained neither gold nor silver.

Gold and silver assays, cont.

Province of British Columbia.

Province of British Columbia.

19.—This and the three following specimens are from Tunnel Mountain, nine miles west of summit of Rocky Mountains. They were taken from different parts of what was stated to be an extensive deposit. Received from Mr. T. S. Higginson.

This specimen consisted of an exceedingly fine granular galena. It was found to contain :—

Gold............. Traces.
Silver........... 3.996 ounces to the ton of 2,000 lbs.

20.—A fine to moderately coarse crystalline galena, through which was disseminated a trifling amount of copper-pyrites; it did not contain any readily discernable gangue. Weight of specimen, ten ounces. Assays gave :—

Gold........... Traces.
Silver........... 4.010 ounces to the ton of 2,000 lbs.

21.—A coarsely crystalline galena, associated with a little copper-pyrites, in a gangue of quartz and calcite—in parts coated with ferric hydrate, and here and there stained with blue and green carbonate of copper; the gangue constituted but a very small proportion, by weight, of the whole. Weight of specimen, five ounces. It contained :—

Gold........... Traces.
Silver........... 11.302 ounces to the ton of 2,000 lbs.

22.—A fine to coarse crystalline galena, associated with a small quantity of iron pyrites; it contained but a very trifling amount of gangue. Weight of specimen, one pound seven ounces. Assays showed it to contain :—

Gold............ Traces.
Silver........... 3.281 ounces to the ton of 2,000 lbs.

23.—From Otter Tail Creek, thirty-eight miles west of summit of Rocky Mountains, and one mile south of the track of the Canadian Pacific Railway. This and the four following specimens were received from Mr. T. S. Higginson.

A white translucent quartz in association with calcite, carrying a coarsely crystalline galena and a little copper pyrites; it was in parts coated with ferric hydrate. The metallic sulphides constituted, approximately, forty per cent., by weight, of the whole. The sample, which was made up of numerous fragments, weighed

two pounds seven ounces. A fair average of the whole was found to contain:—

Gold and silver assays, cont.

Province of British Columbia, cont.

Gold............ Traces.
Silver........... 3.281 ounces to the ton of 2,000 lbs.

24.—From the same locality as the preceding specimen.

It consisted of an association of a coarse crystalline galena and copper-pyrites, in a gangue of white translucent quartz with a little calcite; it was in parts coated with green carbonate of copper and ferric hydrate. The metallic sulphides constituted, approximately, seventy-five per cent., by weight, of the whole. Weight of the specimen, two pounds fifteen ounces. It contained:—

Gold............ Traces.
Silver........... 5.833 ounces to the ton of 2,000 lbs.

25.—Also from the same locality as No. 23.

It consisted of copper pyrites in a gangue of white translucent quartz; it was in parts coated with green carbonate of copper and ferric hydrate. The metallic sulphides constituted, approximately, thirty-nine per cent., by weight, of the whole. Assays gave:—

Gold............ Traces.
Silver........... 0.171 of an ounce to the ton of 2,000 lbs.

26.—From a mountain on the Kicking Horse River, on the line of the Canadian Pacific Railway, forty-nine miles west of the summit of the Rocky Mountains.

A ferruginous dolomite in association with small quantities of a white translucent quartz, and a pale apple-green talcose mineral, and a little calcite; it contained a few specks of iron pyrites, and was in parts coated with ferric hydrate; the whole presented a more or less weathered appearance. Weight of sample, which consisted of numerous fragments, one pound two ounces.

It contained neither gold nor silver.

27.—From Fifteen Mile Creek, Selkirk Mountains.

A white translucent quartz, carrying small quantities of copper pyrites and a trifling amount of a mineral which, in appearance, much resembled tetrahedrite (but which was not identified, as it was considered that the abstraction of a sufficient amount of the material to enable this to be done might not improbably injure the specimen for assay); the whole was more or less seamed and

Gold and silver assays, cont.

Province of British Columbia, cont.

coated with blue and green carbonate of copper and ferric hydrate. Weight of specimen, one ounce. Assays showed it to contain :—

Gold............ Traces.
Silver........... 2.552 ounces to the ton of 2,000 lbs.

28.—From the "International" claim, west side of Kootanie Lake.

A somewhat coarse crystalline galena, associated with a trifling amount of quartz. Weight of specimen, three-quarters of an ounce. This and the five following specimens were received from Mr. Fernie. It was found to contain :—

Gold........... Traces.
Silver........... 10.719 ounces to the ton of 2,000 lbs.

29.—From Bull River, above the bridge. Reported as occurring in large quantity.

A massive, very fine granular haematite, seamed throughout with blue, and occasionally a little green carbonate of copper. Weight of specimen, four and a-half ounces.

It contained neither gold nor silver.

30.—From the "Blue Bell" claim, east side of Kootanie Lake.

The specimen, which weighed one and three-quarter ounces, consisted of an intimate association of iron-pyrites and ferric hydrate, in parts incrusted with an efflorescence of ferrous sulphate, which latter was present in very notable quantity. The pyrites constituted, approximately, two-thirds, by weight, of the whole. Assays gave :—

Gold............ Traces.
Silver........... 1.823 ounces to the ton of 2,000 lbs.

31.—From the "Lu-lu" mine, west side of Kootanie Lake.

A coarse crystalline galena; it did not contain any readily discernable gangue. Weight of specimen, five ounces. Assays showed it to contain :—

Gold............ Traces.
Silver........... 15.458 ounces to the ton of 2,000 lbs.

32.—From mountains near Lower Columbia Lake.

Consisted of chalcocite, seamed and coated with green and blue carbonate of copper; it contained but a very trifling amount of gangue, consisting of quartz. Weight of specimen, three ounces.

It contained neither gold nor silver.

33.—From the Spilimichine River, Purcell Range.

Gold and silver assays, cont.

A fine crystalline galena, through which was disseminated a small quantity of iron-pyrites: it contained a very trifling amount of gangue, consisting of quartz and a ferruginous dolomite. Weight of specimen, eight and a-quarter ounces. It contained:—

Province of British Columbia, cont.

Gold............ Traces.
Silver........... 8.094 ounces to the ton of 2,000 lbs.

34.—From the Briscoe Range, Rocky Mountains, opposite lower end of Upper Columbia Lake. Received from Mr. D. Griffith. Reported as occurring in large quantity.

It consisted of chalcocite and bornite, with some blue and green carbonate of copper and a little copper-pyrites, in association with a colorless sub-transparent to transparent quartz. The gangue constituted but a small proportion, by weight, of the whole. Weight of specimen, one pound seven ounces.

It contained neither gold nor silver.

35.—From Nashwaak River, near Rocky Brook.

A milky white quartz, in parts stained with ferric hydrate; some of the fragments were thickly coated with this latter. Weight of specimen, one pound one and a-half ounce.

It contained neither gold nor silver.

36.—From Cross River, White Man's Pass, Rocky Mountains. Collected by Dr. G. M. Dawson.

A white translucent quartz, carrying a little copper-pyrites; it was in parts stained with green carbonate of copper and ferric hydrate. Weight of specimen, thirteen and three-quarter ounces.

It contained neither gold nor silver.

37.—From the Snow-flake vein, Columbia River. Received from Mr. W. Grier.

A milky white quartz, with numerous cavities and seams filled with ferric hydrate, and here and there a few specks of iron-pyrites. Weight of specimen, two and a-quarter ounces.

It contained neither gold nor silver.

38.—From Cross River, near Upper Forks. Collected by Dr. G. M. Dawson.

A white, somewhat coarsely crystalline dolomite, in parts stained and coated with hydrated peroxide of iron. Weight of specimen, four and a-quarter ounces.

It contained neither gold nor silver.

Gold and silver assays, cont.

Province of British Columbia, cont.

39.—From Beaver Creek, Columbia River. Received from Mr. T. S. Higginson.

A white translucent quartz associated with a small quantity of a greyish hydrous mica; the greater number of the fragments were thickly coated with hydrated peroxide of iron. Weight of specimen, three pounds two ounces.

It contained neither gold nor silver

40.—From the "Queen Mine," Yale Creek, two miles north of the town of Yale. Taken from the surface, at mouth of tunnel.

The material examined consisted of picked specimens taken from a sample, weighing thirteen pounds, of the ore forwarded for exhibition. Some fragments eonsisted of white translucent quartz carrying iron-pyrites, galena and a little zinc-blende,—others consisted of a greyish, somewhat fine granular quartz, in connection with a greyish-green to bright green chromiferous serpentine and, more immediately associated with the latter, some graphite; the whole contained a good deal of finely disseminated iron-pyrites. Assays showed it to contain:

Gold............	traces.
Silver...........	0.292 of an ounce to the ton of 2,000 lbs.

41.—Also from the "Queen Mine," Yale Creek. Taken one hundred and eighty feet in from mouth of tunnel.

The material examined consisted of picked specimens taken from a sample, weighing forty-eight pounds, of the ore forwarded for exhibitfon. It consisted of an association of zinc-blende and iron-pyrites, with a small quantity of white translucent quartz and a trifling amount of a greyish-white talcose mineral. The specimen assayed contained but very little gangue. Assays gave:

Gold............	traces.
Silver...........	2.800 ounces to the ton of 2,000 lbs.

42.—From Fifteen Mile Creek, about six miles from its entry into the Columbia River, Selkirk Mountains.

A milky-white quartz thickly coated with ferric hydrate. Weight of specimen, thirteen ounces. This and the two following specimens were received from and examined for Mr. T. S. Higginson.

It contained neither gold nor silver.

43.—From ten miles west of summit of Selkirk Range, and about one and a-half mile from the line of the Canadian Pacific Railway.

A coarsely crystalline galena, associated with a trifling amount

of copper-pyrites and calcite. This specimen—a very small one, weighing only one ounce,—was found to contain:

Gold and silver assays, cont.

Province of British Columbia, cont.

Gold............	distinct traces.
Silver...........	79.956 ounces to the ton of 2,000 lbs.

44.—From Spilimichine Creek, Columbia River.

A very fine granular galena. It contained but a trifling amount of gangue. Weight of specimen, one pound two ounces. Assays showed it to contain:

Gold............	traces.
Silver...........	4.667 ounces to the ton of 2,000 lbs.

MISCELLANEOUS MINERALS.

Miscellaneous minerals.

1.—Galenite.—From the Silver Islet mine, Lake Superior, Ontario.

Galenite from Silver Islet Mine, Lake Superior.

The specimen in question—which was presented to Mr. E. D. Ingall by Mr. R. Trethewey, jun., as a donation to the Museum of the Survey,—was taken from a vug in the five hundred and sixty foot level, south of the main shaft. It was an aggregation of more or less perfect octahedra, the axes of some of which were five centimetres in length. A portion of one of the crystals was, as a matter of interest, assayed for silver, and found to contain 0.011 per cent. of that metal. Mr. Trethewey states that sometimes as much as a thousand pounds of galena, in the form just referred to, has been taken out of one of these crevices or vugs, and that these have been met with, from time to time, in nearly every level in the mine.

Witherite from Twin City Mine, Thunder Bay, Lake Superior.

2.—Witherite.—From the Twin City mine, near Rabbit Mountain, Thunder Bay, Lake Superior. Collected by Mr. E. D. Ingall of this Survey. He informs me that it occurs in a silver-bearing vein, consisting, for the most part, of calcite and quartz, wlth some fluorite,—the silver occurs both native and as argentite. The specimen was in the form of radiating crystalline globular concretions—one fragment exceeded a pound in weight. The examination was conducted by Mr. F. D. Adams.

So far as I am aware, this is the first time that this mineral has been met with in Canada.

Molybdenite from Aldfield, Pontiac County, P. Que.

3.—Molybdenite.—Some well crystallized specimens of this mineral, from lots one and two of the third range of Aldfield, Pontiac County, have been presented to the Museum of the Survey by Mr. R. H. G. Chapman. Some of the less perfect were of considerable dimensions, one measured about eleven centimetres across, and weighed close upon two and a-half pounds—of the smaller, an almost perfect and very handsome crystal, and which was in the form of a tubular hexagonal prism, measured very nearly five centimetres across.

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ALFRED R. C. SELWYN, LL.D., F.R.S., DIRECTOR.

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